Chapter 1
Elementary and Secondary Education

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999-2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Highlights

Mathematics and Science Achievement

- **Although mathematics and science achievement, as measured by the National Assessment of Educational Progress (NAEP), have improved since the 1970s, few students are attaining levels deemed Proficient or Advanced by a national panel of experts.** For example, only 17 percent of 12th-grade students scored at the proficient level on the NAEP mathematics assessment in 2000.

- **At each grade level, white and Asian/Pacific Islander students are far more likely than their black, Hispanic, and American Indian/Alaskan Native counterparts to score at or above the Basic, Proficient, and Advanced levels set by the National Assessment Governing Board (NAGB).** For example, although 33 percent of Asian/Pacific Islander and 20 percent of white 12th graders scored at the Proficient level in 2000, only 4 percent of Hispanic, 3 percent of black, and 10 percent of American Indian/Alaskan Native 12th graders scored at that level. Furthermore, there was no evidence in the 2000 assessment of any narrowing of the racial/ethnic group score gaps since 1990.

- **There is a wide gap between the NAEP mathematics scores of high-and low-income students, as measured by eligibility for the National School Lunch Program.** For example, low-income 12th-grade students (those who were eligible for the Free/Reduced Price Lunch Program) had scale scores similar to high-income 8th-grade students (those who were not eligible for this program). Furthermore, at each grade level, low-income students were twice as likely or more to score below the Basic level of achievement than were high-income students.

- **Internationally, U.S. student relative performance becomes increasingly weaker at higher grade levels.** On the Third International Mathematics and Science Study (TIMSS), 9-year-olds tended to score above the international average, 13-year-olds near the average, and 17-year-olds below it. Even the most advanced students performed poorly compared with students in other countries taking advanced mathematics and science courses. On advanced mathematics and science assessments, U.S. students who had taken advanced coursework in these subjects performed poorly compared with their counterparts in other countries.

Coursetaking

- **Since the publication of *A Nation At Risk* nearly 20 years ago, most states have increased the number of mathematics and science courses required for high school graduation.** As of 2000, 25 states required at least 2.5 years of math and 20 states required 2.5 years of science; in 1987, only 12 states required that many courses in math and only 6 required that many courses in science. Opinions differ, however, on the quality of the added courses, especially those taken by students who are low achievers.

- **In 1998, more graduating students had taken advanced mathematics and science courses than did their counterparts in the early 1980s.** For example, almost all graduating seniors (93 percent) in the class of 1998 had taken biology, more than one-half (60 percent) had taken chemistry, and more than one-quarter (29 percent) had completed physics. Participation rates in advanced placement or honors science courses are considerably lower: 16 percent for biology, 5 percent for chemistry, and 4 percent for physics.

- **Female and male students have broadly similar coursetaking patterns, although there are some differences.** In high school, girls are as likely as boys to take advanced mathematics classes and are more likely to take biology and chemistry; they remain less likely to take physics.

- **Students in all racial and ethnic groups are taking more advanced mathematics and science courses, although black, Hispanic, and American Indian/Alaskan Native graduates still lag behind their Asian/Pacific Islander and white counterparts in advanced mathematics and science coursetaking.** For example, graduates in the class of 1998 who had taken algebra II ranged from 47 percent of American Indians/Alaskan Natives to 70 percent of Asians/Pacific Islanders. Percentages for white, black, and Hispanic graduates were 65, 56, and 48, respectively. Furthermore, Asians/Pacific Islanders were a third more likely than whites to take calculus (18 versus 12 percent) and three times more likely than blacks, Hispanics, and American Indians/Alaskan Natives (about 6 percent each).

Content Standards and Statewide Assessments

- **In the 1980s, most states approved policies aimed at improving the quality of K–12 education by implementing statewide curriculum guidelines and frameworks as well as assessments.** By 2000, 49 states had established content standards in mathematics and 46 states had established science standards. Teachers remain concerned, however, that standards do not always provide clear guidance regarding the goals of instruction and that schools do not yet have access to top-quality curriculum materials aligned with the standards.

- **Although some states have recently delayed the introduction of high-stakes tests (i.e., tests that students must pass to either graduate or advance a grade), public support for standards-based reform appears to be strong.** For example, in a 2000 survey, relatively few parents said that their child's school requires them to take too many standardized tests to the detriment of other important learning (11 percent), that teachers in their child's school "focus so much on preparing for standardized tests that real learning is neglected" (18 percent), or that their child receives too much homework (10 percent).

- **Employers and professors are far more disapproving than parents or teachers of how well young people are prepared for college and work, and very large majorities continue to voice significant dissatisfaction about students' basic skills.** For example, in a 2000 survey, about two-thirds of professors found the basic math skills of recent freshmen and sophomores to be only "fair" or "poor." More than 80 percent stated that student ability to write clearly was only "fair" or "poor." These results point to the continuing gap between student skill level and preparation for college and college professors' views of the adequacy of that preparation. Results were similar for employers regarding recent job applicants.

- **Public school teachers generally support the movement to raise standards, but they are less supportive than the general public.** The vast majority of public school teachers feel that the curriculum is becoming more demanding of students, although they also feel that new statewide standards have led to teaching that focuses too much on state tests and that a significant amount of "teaching to the test" occurs.

Curriculum and Instruction

- **Students in the United States receive at least as much classroom time in mathematics and science instruction as students in other nations:** for 8th graders, close to 140 hours per year in mathematics and 140 hours per year in science. Students in Germany, Japan, and the United States spent about the same amount of time on a typical homework assignment, although American students were assigned homework more often.

- **According to a curriculum analysis conducted as a part of TIMSS, curriculums and textbooks used in U.S. schools are highly repetitive, contain too many topics, and provide inadequate coverage of important topics.** Independent judges determined that only 6 of the 13 U.S. mathematics texts and none of the 9 U.S. science texts that were evaluated were satisfactory based on 24 instructional criteria. These findings are supported by math and science textbook analyses undertaken by the American Association for the Advancement of Science.

- **Instruction in U.S. 8th-grade classrooms focuses on development of low-level skills rather than on understanding and provides few opportunities for students to engage in high-level mathematical thinking.** A team of mathematicians found that 13 percent of Japanese lessons in 1995 were judged to be of low quality, whereas 87 percent of lessons from U.S. classrooms were judged to be of low quality.

Teacher Quality

- **Research suggests that the following factors are associated with teacher quality: having a high level of academic skills, teaching in the field in which the teacher was trained, having more than a few years of experience (to be most effective), and participating in high-quality induction and professional development programs.**

Teacher Working Conditions

- **The difference between the annual median salaries of all bachelor's degree recipients and teachers has declined over the past 20 years, mainly due to increases in the relative size of the older teaching workforce and in salaries of older teachers.** The average annual median salary of full-time teachers grew slowly during the 1990s, reaching $35,099 in 1998.

- **Teacher pay scales in the United States tend to be lower than those in a number of other countries, including Germany, Japan, South Korea, and the Netherlands.** In addition, teaching hours tend to be longer in American schools. The gaps are particularly wide at the upper secondary (high school) level because a number of countries require higher educational qualifications and pay teachers significantly more at this level than at the primary (elementary) level.

Information Technology in Schools

- **Computers and Internet access are becoming increasingly available in schools, although the distribution of these resources is not uniform.** In 2000, the ratio of students to instructional computers in public schools was 5:1, down from 6:1 in 1999 and a dramatic change from 125:1 in 1983. The ratio of students per instructional computer with Internet access in public schools declined from 12:1 in 1998 to 9:1 in 1999 and then to 7:1 in 2000.

- **Although gaps in access to computers and the Internet have narrowed between high-and low-poverty schools, differences remain.** For high-poverty schools (those with 75 percent or more students eligible for free or reduced-price lunch), 60 percent of all instructional rooms had Internet access in 2000, up from 5 percent in 1996. Schools with less poverty tended to have a larger percentage of rooms with Internet access—77 percent or higher in 2000, up from 11–17 percent in 1996.

- **In 1999, approximately half of the public school teachers who had computers or the Internet available in their schools used them for classroom instruction.** Teachers assigned students to use these technologies for word processing or creating spreadsheets most frequently (61 percent), followed by Internet research (51 percent), problem solving and data analysis (50 percent), and drills (50 percent).

- **Many teachers feel unprepared to integrate technology into the subjects they teach, and relatively few teachers find the current training activities in information technology very useful.** In 1999, only one-third of teachers reported feeling well prepared or very well prepared to use computers and the Internet for classroom instruction, with less experienced teachers indicating they felt better prepared to use technology than their more experienced colleagues. For many instructional activities, teachers who reported feeling better prepared to use technology were generally more likely to use it than were teachers who indicated that they felt unprepared.

Transition to Higher Education

- **Expectations for college attendance have increased dramatically over the past 20 years, even among low-performing students.** Overall, immediate college enrollment rates for high school completers increased from 49 to 63 percent between 1972 and 1999. Much of the growth in these rates between 1984 and 1999 was due to increases in the immediate enrollment rates for females at four-year institutions.

- **Since 1984, college transition rates for black graduates have increased faster than those for whites, thus closing much of the gap between the two groups. The enrollment rates for Hispanic graduates are lower and have been relatively stable over the past 20 years.** In 1994, white graduates were twice as likely to enroll in a four-year college as a two-year college after high school, black graduates were about 1.5 times as likely, and Hispanic graduates were equally likely to enroll in a four-year college as a two-year college.

- **High school graduates from low-income families enter four-year institutions at lower rates than those from high-income families.** Although financial barriers to college attendance exist for many low-income students, another reason for their lower enrollment rate is that they are less qualified academically.

- **Remedial work is widespread at the college level, particularly in two-year colleges.** In 1995, the latest year for which data are available, all public two-year and 81 percent of public four-year institutions offered remedial reading, writing, or mathematics courses. Moreover, freshmen at public two-year institutions were almost twice as likely as their peers at public four-year institutions to enroll in remedial courses in these subjects (41 percent versus 22 percent).

Introduction

This chapter focuses on several key issues at the heart of the current debate over the quality of our elementary and secondary mathematics and science education system. Trends in math and science achievement and coursetaking are examined first, both as system outputs and as the context for current reform efforts. Next, the chapter examines several quantifiable aspects of current reform efforts. Maintaining the science and engineering (S&E) pipeline and preparing all young people for an increasingly technological society are two goals driving reforms targeted to raise the academic bar for students and improve the quality of teaching. The desire to raise the academic expectations for all students has led states to both adopt standards specifying what students should know and be able to do and to implement new testing mechanisms to measure what students actually know.

Although it is widely recognized that education reforms cannot be successful without actively engaging teachers, comprehensive, valid measures of change in teacher quality are difficult to come by, leaving us to rely on currently available data. Indicators of teacher credentials, experience, and participation in professional development activities are presented, as well as data on how new teachers are being inducted into the profession. As access to computers and the Internet becomes more widespread in schools, the focus of the chapter turns toward understanding how IT is being implemented and how students are benefiting from its use. In conclusion, the adequacy of student preparation for higher education is examined as a lead into the discussion of college-level S&E in chapter 2.

This chapter emphasizes variation in both access to education resources (by school poverty level and minority concentration) and performance (by sex, race/ethnicity, and family background) as data availability allows. A distinction is also made between mathematics and science when the policy implications of data are different or the data tell different stories.

How Well Do Our Students Perform in Mathematics and Science?

U.S. and internationally comparable achievement data result in a mixed report card for the United States. Although performance on assessments of mathematics and science achievement by the National Assessment of Educational Progress (NAEP) has improved since the 1970s, few students are attaining levels deemed Proficient or Advanced by a national panel of experts, and the performance of U.S. students continues to rank substantially below that of students in a number of other, mostly Asian, countries. This cross-national achievement gap appears to widen as students progress through school. This section describes progress in student performance, both long-term trends based on NAEP curricular frameworks developed in the late 1960s and more recent trends that track performance across items aligned with more current standards. International comparisons are then used to benchmark U.S. performance in these subjects.

Long-Term Trends in Math and Science Performance

Generally, mathematics and science performance on the NAEP long-term trend assessment declined in the 1970s, increased during the 1980s and early 1990s, and has remained mostly stable since that time. (See sidebar, "The NAEP Trends Study.") NAEP mathematics achievement increased among 9-, 13-, and 17-year-old students since the early 1980s, although most of these gains occurred before 1992. (See figure 1-1.) Although the average scale scores of 17-year-olds declined by 6 points between 1973 and 1982, scores increased by 9 points between 1982 and 1992 and remained at about the same level through 1999 (National Center for Education Statistics (NCES) 2000e). These gains since 1982 were substantial, equating to about a quarter of the difference between the mathematics scores of 13- and 17-year-olds (an 8-point difference is roughly equivalent to a year of schooling between these ages). Substantial gains were also made by 9- and 13-year-olds between 1982 and 1999: 8 and 13 points, respectively.

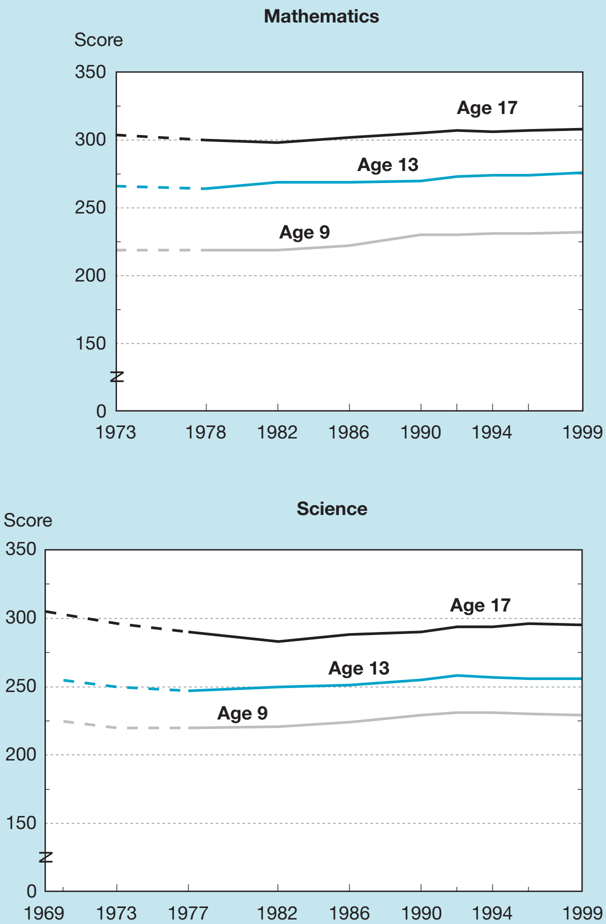
NAEP science performance over the past three decades has generally mirrored that of math: scores declined during the 1970s but increased in the 1980s and early 1990s. Because the first science assessments occurred before the first math assessments (1969 for 17-year-olds and 1970 for 13- and 9-year-olds), science achievement can be tracked over a longer period. Results for 17-year-olds show an initial 22-point decline between 1969 and 1982. In the decade between 1982 and 1992, an increase in the average score erased about half of that decline; since 1992, scores have been stable. (See figure 1-1.) Although 17-year-olds had higher science scores in 1999 than their counterparts in 1982, the average 1999 score remained 10 points below the average score in 1969. Gains since the early 1980s for 13- and 9-year-olds in science have essentially returned the average scores of these cohorts to levels similar to (for 13-year-olds) or higher than (for 9-year-olds) those posted in 1970.

A persistently wide gap in NAEP scores between low- and high-performing students remains. For example, the gap between the average mathematics scores of the highest and lowest performing quartiles for 17-year-old students was 73 points in 1999, a gap similar in size to the difference between the average scale scores for 17- and 9-year-olds in 1999 (roughly equivalent to eight years of schooling). Similar gaps have persisted for 9- and 13-year-olds as well. Efforts to apply uniformly high standards to all children need to confront the large variation in performance that currently exists in our schools.

Trends in Performance by Sex

Differences in the academic performance of female and male students on the NAEP long-term trend assessment appear as early as age 9 and persist through age 17. Although girls have consistently outperformed boys in reading and writing, gaps between the sexes in mathematics and science performance in the early grades have been much narrower and have varied over time. In 1999, 9-year-old girls had higher

Figure 1-1.
Trends in average scale scores in mathematics and science: 1969–1999



NOTE: Dashed lines represent extrapolated data.

SOURCE: National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance,* NCES 2000-469. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2000e.

Science & Engineering Indicators – 2002

The NAEP Trends Study

The National Assessment of Educational Progress's (NAEP's) long-term trend assessments have been the primary means for tracking the achievement trends of 9-, 13-, and 17-year-olds in science since 1969 and in mathematics since 1973. These primarily multiple-choice tests have remained substantially the same since first given, allowing the measurement of student progress over the past three decades. The content of these assessments is "traditional" by today's standards. For example, the mathematics assessment measures student knowledge of basic facts, ability to carry out numerical algorithms using paper and pencil, knowledge of basic measurement formulas as they are applied to geometry problems, and ability to apply mathematics to daily living skills (such as those related to time and money). Calculators are permitted only on a few questions. The computational focus of the long-term trend assessment provides the opportunity to determine how our students are measuring up to traditional procedural skills, even as the calculator plays an increasingly greater role in today's mathematics curriculum. Both the content (see the section, "Benchmarking of Mathematics Performance Against Standards") and the populations assessed, which are age groups rather than grades, distinguish these assessments from the "National" NAEP, which is discussed in the next section.

Student performance on the long-term trend assessments is summarized on a 0- to 500-point scale for each subject area. Item response theory (IRT) was used to estimate average proficiency for the nation and various subgroups of interest within the nation. IRT models the probability of answering a question correctly as a mathematical function of proficiency or skill. The main purpose of IRT analysis is to provide a common scale by which performance can be compared across groups, such as those defined by age, assessment year, or subpopulations (e.g., race/ethnicity or sex). Although the use of IRT scaling in the NAEP Trends Study puts the scores of 9-, 13-, and 17-year-olds on the same scale, which facilitates comparisons across ages, the scores of students on the Third International Mathematics and Science Study (TIMSS) are scaled separately for each grade. Therefore, the scores are not comparable across grades.

SOURCE: NCES 2000e and <http://www.nces.ed.gov/naep3/mathematics/trends.asp>.

average reading scores than boys, although this gap has narrowed since 1971 (NCES 2000e). In mathematics, higher scores earned by girls in the 1970s shifted to higher scores earned by boys in the 1990s. In 1999, however, the difference between the scores of boys and girls was not statistically significant. In science, boys have tended to perform better than girls at age 9, although, as observed in mathematics, the difference in 1999 was not statistically significant.

Female and male achievement differences at age 9 remain nearly unchanged at age 13. For example, in 1999, the average reading proficiency score for a 13-year-old female was 12 scale points higher than for a 13-year-old male, and females scored at about the same level in math and 6 scale points lower than males in science (NCES 2000e). When 17-year-olds are assessed, female and male differences in reading persist. For example, in 1999, average reading proficiency for 17-year-old females was 13 scale points higher than for males of the same age. This corresponds to about 45 percent of the difference between the average scores of 13- and 17-year-olds in 1999. In other words, the gap in reading proficiency between females and males at age 17 is roughly equivalent to between 1.5 and 2 years of schooling.

In mathematics and science, boys have tended to score higher than girls, although the gap is narrower. A gap favoring 17-year-old males in mathematics narrowed from 8 points in 1973 to one that was statistically insignificant in 1999. (See figure 1-2.) The gap in science at this age narrowed from 16 points in 1973 to 10 points in 1999 (about a year's worth of science).

Trends in Performance by Race/Ethnicity

NAEP trend data on science and mathematics achievement of 17-year-olds between 1973 and 1999 suggest that the gap between whites and their black and Hispanic peers has narrowed but remains large.[1] Differences in percentile scores by race/ethnicity, that is, the score at which different percentages of a particular group (5, 25, 50, 75, or 95 percent) score at or below, provide an indication of the size of these gaps. (See figure 1-3.) For example, in 1999, 75 percent of white 17-year-olds scored 282 or above on the NAEP science test (the 25th percentile score), while only 25 percent of black 17-year-olds and fewer than 50 percent of Hispanic 17-year-olds scored at that level. In mathematics, the gap between blacks and whites appears to be somewhat narrower and the gap between whites and Hispanics somewhat wider. Gains by both high- and low-performing black and Hispanic students have narrowed the wide gaps that were in evidence since 1973, although there is little evidence that the gaps have continued to narrow in the 1990s, and some evidence that the gap between whites and blacks in mathematics has widened (NCES 2000e).

Gaps in mathematics achievement between whites and other racial/ethnic groups exist before entering high school, but evidence shows that these gaps widen for some groups during high school. In mathematics, the overall differences in 8th- to 12th-grade achievement gains show that blacks learn less than whites during high school, Hispanics and whites do not differ significantly, and Asians learn more than whites on average. However, when one compares blacks and whites completing the same number of math courses, the achievement gains during high school are not measurably (statistically) different. The Asian and white achievement gain differences are also generally reduced among students completing the same number of mathematics courses (NCES 1995). These data do not suggest, however, that coursetaking patterns alone lead to similar outcomes. The level of achievement that students from different backgrounds have attained before entering particular courses makes a difference, because parallel gains among students taking the same courses cannot close the gap. For example, NAEP data show that racial/ethnic differences in mathematics persist even among students who have completed similar courses at the time of assessment. The gap in average scores was 21 points between white and black 17-year-olds whose highest math course taken as of the 1996 assessment was algebra II; this gap is similar to the difference in scores observed between all 17-year-olds whose highest math course was algebra II and those whose highest course was geometry (NCES 2000b).

Benchmarking of Mathematics Performance Against Standards

In addition to the long-term trend data described above, NAEP periodically assesses the mathematics and science performance of students against more current frameworks of what students are expected to know in the 4th, 8th, and 12th grades (hereafter, referred to as the "National" NAEP).[2] Since 1990, the mathematics assessments have been based on a framework influenced by the National Council of Teachers of Mathematics (NCTM) Curriculum and Evaluation Standards for School Mathematics (NCTM 1989). The assessment framework contains five content strands (number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics, and probability; and algebra and functions). In addition to the five content strands, the assessments examine mathematical abilities (conceptual understanding, procedural knowledge, and problem solving) and mathematical power (reasoning, connections, and communication). Student mathematics performance is summarized on the NAEP mathematics scale, which ranges from 0 to 500. In addition, results for each grade are reported according to three achievement levels developed by NAGB: Basic, Proficient, and Advanced. These achievement levels are based on collective judgments by NAGB about what students should know and be able to do in mathematics.[3] The levels were defined by a broadly representative panel of teachers, education specialists, business and government leaders, and members of the general public. The Basic level denotes partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade. The Proficient level represents solid academic performance as determined by NAGB, and the Advanced level signifies superior performance. Although NCES still considers these proficiency levels developmental, they are used in this section to benchmark student math achievement.

Mathematics Performance by Achievement Level

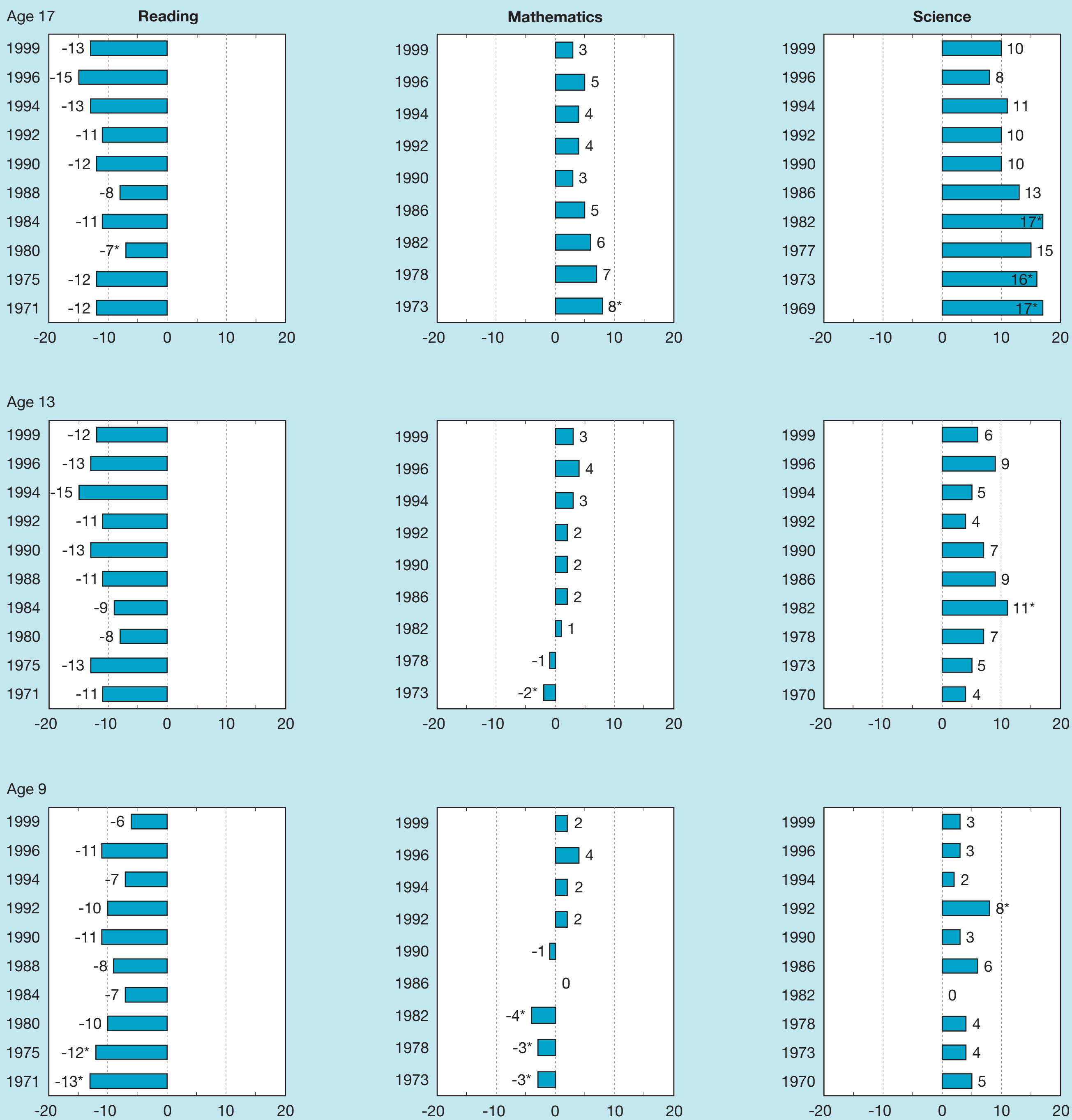
Although mathematics trends in the NAEP long-term trend study were relatively flat during the 1990s, mathematics per-

[1]Hispanics are a diverse group with considerable differences in country of origin, social class, race, educational status, and level of assimilation (Valdivieso and Nicolau 1992). What does characterize all the major groups except Cubans, albeit in varying intensities, are high levels of poverty and low levels of educational achievement. Although sample sizes in the data presented in this chapter do not allow the separate reporting of Hispanics by background characteristics, it should be acknowledged that there is a wide range of variability within this broad category. Sample sizes for Asians/Pacific Islanders and American Indians/Alaskan Natives are too small in the NAEP trends study to produce reliable estimates for these groups.

[2]Data from the 2000 NAEP Science Assessment were not available in time for inclusion in this chapter. The main findings were that 4th- and 8th-graders' scores remained stable between 1996 and 2000, while scores for high school seniors declined. See < http://nces.ed.gov/nationsreportcard/science/results/>. Accessed 11/26/01.

[3]A recent National Academy of Sciences-commissioned report found the current process of setting NAEP achievement levels to be "fundamentally flawed" (National Research Council 1998, 162). NAGB continues to use the mathematics achievement levels developed for the 1990 assessment, and they are used here because they so clearly highlight the widespread concern about the level of student performance in this subject.

Figure 1-2.
Trends in differences between male and female student average scale scores, by age, various years: 1969–1999
(Male minus female score)



*Significantly different from 1999. Small differences between male and female scores are often not statistically significant. For example the male-female differences were not statistically significant in 1999 for mathematics at all three ages and for 9-year-olds in science.

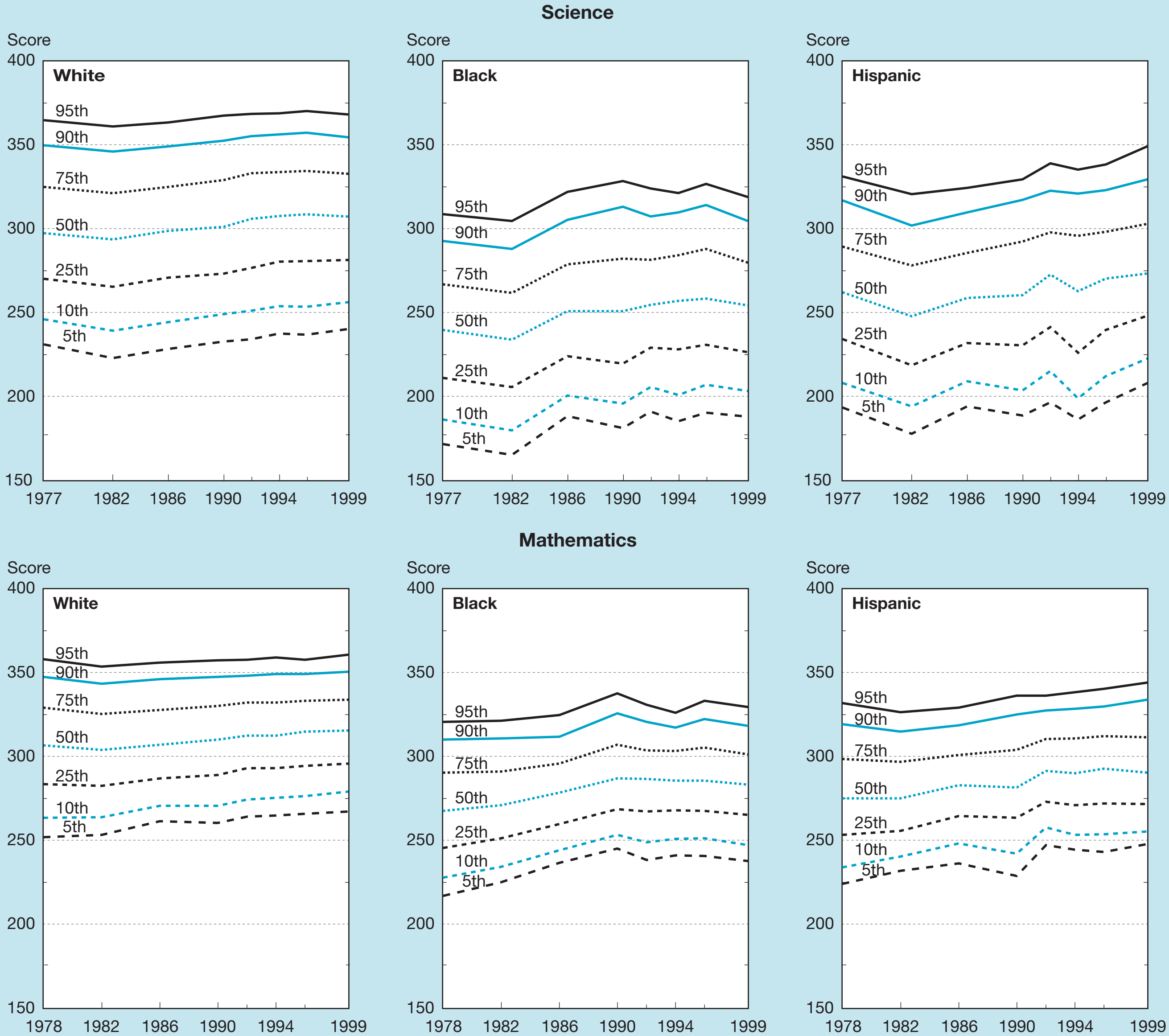
SOURCE: National Center for Education Statistics, *NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance,* NCES 2000-469. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2000e.

Science & Engineering Indicators – 2002

formance on the National NAEP increased in the 4th, 8th, and 12th grades between 1990 and 2000. While the average scores of 4th and 8th graders made progress throughout the decade, the scores of 12th graders declined between 1996 and 2000, reducing some of the gain made between 1990 and 1996. The national average scale score for 4th graders in 2000 was 228, an increase of 15 points over the national average for 1990; the average scale score for 8th graders in 2000 was 275, an increase of 12 points; and the average scale score for 12th graders was 301, an increase of 7 points since 1990, but a decrease in 3 points since 1996 (NCES 2001f). The cross-decade increases of 4th and 8th graders are between a third and almost half of a standard deviation in test scores for these grades, roughly equivalent to a gain of between 1.5 and 2 grade levels. While smaller, the 12th-grade gain was still substantial, between 0.5 and 1 grade level.

Although these increases suggest that some progress is being made across areas emphasized in the NCTM mathematics standards, relatively few students scored at the Proficient or Advanced levels set by NAGB for each grade, and more than 30 percent scored below the Basic level. (See figure 1-4.) For 4th-grade students, the percentage performing at or above the Basic level was 69 percent in 2000 compared with 50 percent in 1990; for 8th-grade students, 66 percent compared with 52

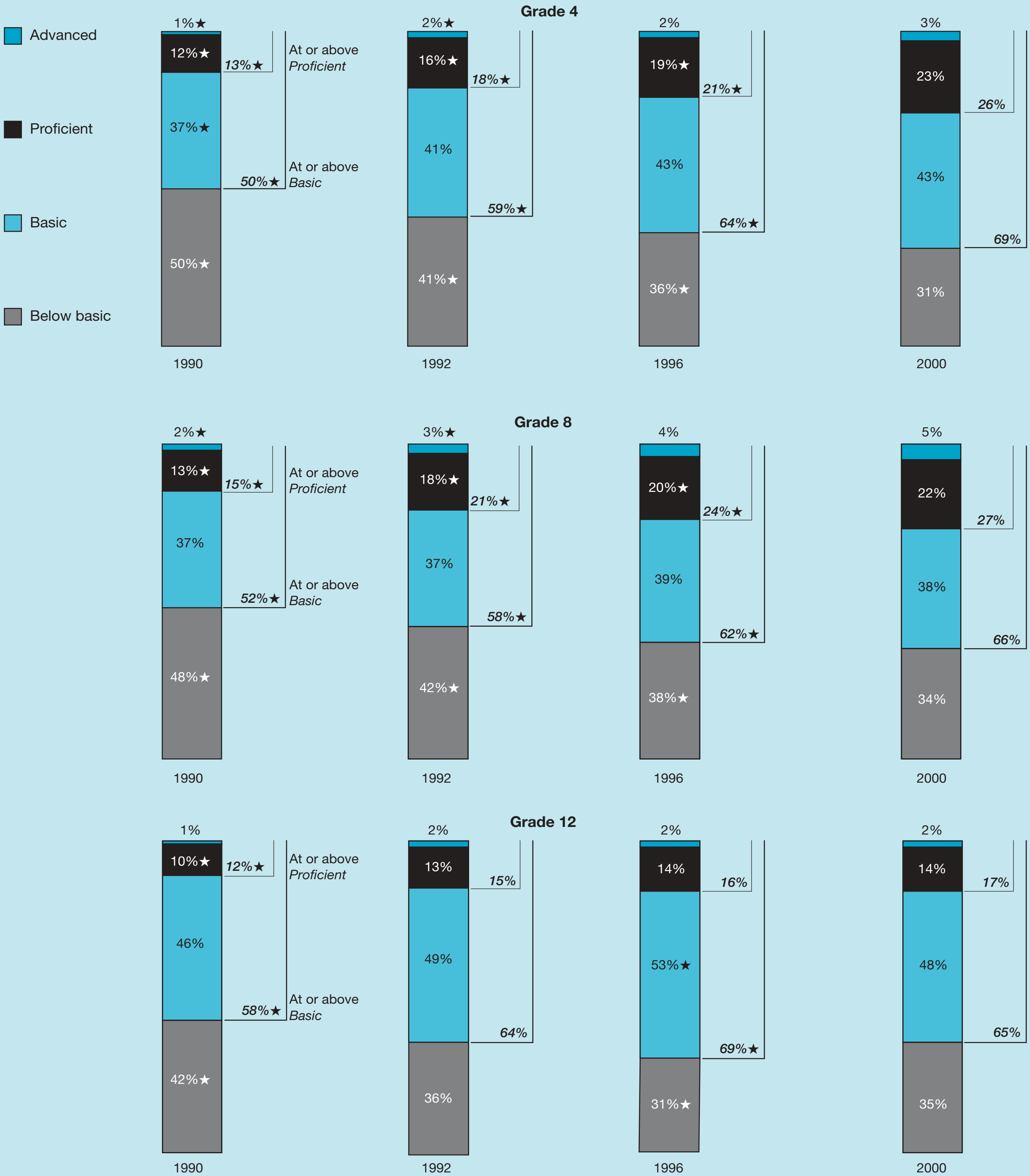
Figure 1-3.
Percentile distribution of science and mathematics proficiency for 17-year-olds, by race/ethnicity: selected years 1977–99



SOURCE: U.S. Department of Education, National Center for Education Statistics, National Assessment of Educational Progress, summary data tables http://nces.ed.gov/nationsreportcard/tables/.

Science & Engineering Indicators – 2002

Figure 1-4.
Percentage of students within each mathematics achievement level range and at or above achievement levels, grades 4, 8, and 12: 1990–2000



How to read these figures:
The italicized percentages to the right of the shaded bars represent the percent of students at or above *Basic* and *Proficient.*
The percentages in the shaded bars represent the percentages of students within each achievement level.
★ Significantly different from 2000.

NOTE: Percentages within each mathematics achievement level range may not add to 100, or to the exact percentages at or above achievement levels, due to rounding.

SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000,* NCES 2001-517, Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2001f.

Science & Engineering Indicators – 2002

percent; and for 12th-grade students, 65 percent compared with 58 percent. The percentages of students scoring at the Proficient and Advanced levels were much lower: 26 percent of 4th graders, 27 percent of 8th graders, and 17 percent of 12th graders scored at the Proficient level in 2000, and the percentage of students in these grades in 2000 scoring at the Advanced level were 3 percent, 5 percent, and 2 percent, respectively. From NAGB's perspective, then, as many as one-third of students continue to score below a Basic level of mathematics achievement, and few score at levels considered to be Advanced.

Proficiency levels provide an additional metric to gauge how wide the gaps in scores are between different subgroups. The NAEP sample shows differences in the achievement of boys and girls, students from different racial and ethnic groups, students from different states and jurisdictions, and students receiving and not receiving Title I services.

Proficiency by Sex

Although similar proportions of boys and girls scored at the Basic level or above on the 2000 NAEP mathematics assessment, boys were more likely to score at the Proficient or Advanced levels than girls at the 4th, 8th, and 12th grades. For example, 20 percent of 12th-grade males scored at the Proficient level compared with 14 percent of girls, and the percentage of each group scoring at the Advanced level was 3 and 1 percent, respectively. (See text table 1-1.)

Proficiency by Race/Ethnicity

At each grade level, a larger percentage of white and Asian/Pacific Islander students scored at the Basic, Proficient, and Advanced levels in 2000 than their black, Hispanic, and American Indian/Alaskan Native counterparts.[4] For example, while 34 percent of Asian/Pacific Islander and 20 percent of white 12th graders scored at or above the Proficient level in 2000, only 4 percent of Hispanic, 3 percent of black, and 10 percent of American Indian/Alaskan Native 12th graders scored at that level. Furthermore, there was no evidence in the 2000 assessment of any narrowing of the racial/ethnic group score gaps since 1990. These differences, combined with higher dropout rates for Hispanic, black, and American Indian/Alaskan Native youth, point to considerable disparities in achievement across racial/ethnic groups. However, there is substantial variation for ethnic groups by country of origin (see sidebar, "Variation in Educational Achievement and College Attendance Rates of Asian and Hispanic 1988 8th Graders by Country of Origin") and time since immigration. (The sidebar, "Generational Status and Educational Outcomes Among Asian and Hispanic 1988 8th Graders" compares ethnic groups by timing of immigration.)

Text table 1-1.
Percentage of 12th-grade students at each NAEP mathematics achievement level: 1990 and 2000

Year and characteristic	Advanced	Proficient	Basic	Below basic
Total				
2000	2	17[a]	65[a]	35[a]
1990	1	12	58	42
Male				
2000	3	20	66[a]	34[a]
1990	2	15	60	40
Female				
2000	1	14[a]	64[a]	36[a]
1990	1	9	56	44
Race/ethnicity				
White				
2000	3	20[a]	74[a]	26[a]
1990	2	14	66	34
Black				
2000	—	3	31	69
1990	0	2	27	73
Hispanic				
2000	—	4	44[a]	56[a]
1990	—	4	36	64
Asian/Pacific Islander				
2000	7	34	80	20
1990	5	23	75	25
American Indian/Alaskan Native[b]				
2000	—	10	57	43
Location (2000)				
Central city	2	16	60	40
Urban fringe/large town	3	19	68	32
Rural/small town	1	13	65	35

— = Percentage is between 0.0 and 0.5.

[a]Significantly different from 1990 at 0.5 level.

[b]Sample size is insufficient to permit a reliable estimate of 1990 values.

SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000,* NCES 2001-517, Washington DC: U.S. Department of Education, Office of Educational Research and Improvement 2001e.

Science & Engineering Indicators – 2002

Proficiency by Type of Location

At the 4th, 8th, and 12th grades, students in the urban fringe/large town locations had higher scale scores on the NAEP national mathematics assessment than students in central city locations (NCES 2001f). At grades 4 and 8, students in rural/small town locations also outperformed their counterparts in the central city locations. These differences were also reflected in proficiency scores. (See text table 1-1.) For example, at grade 12, there were higher percentages of students at or above the Proficient level and at or above the Advanced level attending schools in urban fringe/large town locations (19 and 3 percent, respectively) than in rural school locations (12 and 1 percent, respectively). While 16 percent of 12th graders in central city

[4]Sample sizes in the NAEP study are too small to report Asians by country of origin. Reporting a single category of all Asians/Pacific Islanders, however, "conceals complexities and differences in the lives of distinct Asian groups" (Carter and Wilson 1997).

Variation in Educational Achievement and College Attendance Rates of Asian and Hispanic 1988 8th Graders by Country of Origin

Sample sizes in the National Assessment of Educational Progress (NAEP) trends study and the National NAEP are too small to report scores for Asians/Pacific Islanders and Hispanics by country of origin. Collapsing all Asians/Pacific Islanders and all Hispanics into homogeneous ethnic categories can conceal wide variation in outcomes by country of origin. Data collected in the National Educational Longitudinal Study of 1988 show mathematics and science achievement differences between Asian and Hispanic 8th graders from different countries of origin when tested in 1992. This study also compares college attendance rates between Asian/Pacific Islander and Hispanic subgroups. (See text table 1-2.) Data show the following.

Asians/Pacific Islanders

Although the aggregate group of Asians/Pacific Islanders scored as well as or higher than their white counterparts on assessments of mathematics and science in 1992, considerable variation was seen within this group by country of origin. For example, students with ancestry in China, Korea, and South Asia tended to have higher scores than Asians/Pacific Islanders as a whole, and Pacific Islanders had lower scores.

College attendance rates among Asians/Pacific Islanders also varied by country of origin. For example, nearly 9 out of 10 Chinese, Filipino, Korean, and South Asian students in the 8th-grade class of 1988 had enrolled in postsecondary education by 1992, compared with enrollment rates of only 50 percent for those from Pacific Islands.

Hispanics

Hispanic 8th graders with Cuban ancestry tended to have higher mathematics and science test scores than their Mexican American counterparts. Mexican American students also tended to have lower rates of postsecondary attendance than Hispanics with Cuban, Puerto Rican, or other ancestry.

SOURCE: NCES 2001e.

Text table 1-2.
Percentile scores on mathematics and science tests in 1992 and postsecondary enrollment rates by 1994 of 1988 8th-grade class, by race/ethnicity and country of origin

Race/ethnicity and country of origin	1992 Percentile score		Postsecondary enrollment rate by 1994
	Mathematics	Science	
All students	51	51	65
White	56	56	68
Black	33	29	57
American Indian/ Alaskan Native	29	29	35
Asian/Pacific Islander	60	54	83
China	76	65	94
Philippines	62	57	89
Japan	69	67	65
Korea	75	69	95
Southeast Asia	61	52	79
Pacific Islands	39	35	50
South Asia	71	66	91
Hispanic	39	37	54
Mexico	37	37	51
Cuba	53	46	66
Puerto Rico	42	41	65
Other	46	43	67

SOURCE: National Center for Education Statistics, National Education Longitudinal Study: 1988–94, Data Analysis System 2001d.

Science & Engineering Indicators – 2002

locations scored at or above the Proficient level, only 60 scored at or above the basic level, lower than the 68 percent in urban fringe/large town locations.

Because of slight changes by the Census Bureau in the definitions of these categories, schools were not classified in exactly the same way in 2000 in terms of location type as in previous NAEP assessments. Therefore, comparisons to previous years are not possible (NCES 2001f).

Proficiency by Free/Reduced-Price Lunch Eligibility

There is a wide gap between the NAEP mathematics scores of high- and low- income students, as measured by eligibility for the National School Lunch Program. At the 4th, 8th, and 12th grades, the scale scores for students who are not eligible for the Free/Reduced Price Lunch Program (i.e., those above the poverty guidelines) are significantly higher than the scores for the students who are eligible for the program. For example, low-income 12th-grade students (those who were eligible for the Free/Reduced Price Lunch Program) had scale scores similar to high-income 8th-grade students (those who were not eligible for this program). The size of these gaps can also be seen by comparing the percentage of students in each group at or above the Proficient level. While 35 percent of high-income students scored at or above the Proficient level, only 10 percent of their low-income counterparts did so. Furthermore, at each grade level, low-income students were twice as likely or more to score below the Basic level of achievement than were high-income students (NCES 2001f).

Proficiency by State

Wide variability exists across states in the proportion of public 8th-grade students performing above the Proficient level, and growth seen at the national level between 1996 and 2000 was not uniform across states. At grade 8, between 8

Generational Status and Educational Outcomes Among Asian and Hispanic 1988 8th Graders

Past research has consistently shown that, compared with Hispanics, Asian students perform better in school, have higher expectations for educational attainment, are more likely to graduate from high school, and are more likely to continue their education past high school (Sanderson et al. 1996, Green et al. 1995). Most of these studies, however, report statistics and findings without regard to differences within these groups, such as immigrant status (whether or not the student is foreign or U.S. born) and generational status (the number of generations the student's family has lived in the United States). A recent study from the National Center for Education Statistics (NCES) examined the relationship between the immigration and "generational" status of Asian and Hispanic students and various educational indicators and outcomes. Students were classified as:

- first-generation immigrant (born outside the United States);
- second-generation immigrant (U.S.-born students with one or both parents born outside the United States); or
- third-generation or higher immigrant (both parents and the student born in the United States). Students born in Puerto Rico who moved to one of the 50 states or the District of Columbia were classified as immigrants.

The analysis looked at how the generational status of Asian and Hispanic students from the 1988 8th-grade cohort of the National Education Longitudinal Study of 1988 (NCES 1999d) was associated with various educational outcomes as this cohort entered and progressed through high school and began postsecondary education. The analysis makes comparisons both *within* race/ethnicity and *between* generations on student background (family and language characteristics); 8th-grade experiences (8th-grade school characteristics, achievement test scores, and plans for high school); high school experiences (type of high school and graduation rates); postsecondary expectations (student and parental); and postsecondary enrollment. The results of this study are summarized below.

Student Background Characteristics

Nearly half of 8th-grade Asians in 1988 were born outside the United States, compared with about 18 percent of their Hispanic peers. Families of first-generation Asian 8th graders were more likely to be from Southeast Asia (23 percent), the Philippines (19 percent), China (19 percent), and Korea (11 percent) than from Japan (1.7 percent) or the Pacific Islands (1.6 percent). The families of third-generation (or greater) Asian 8th graders were more likely than their first-generation counterparts to be from other Asian countries, including India (50 percent), the Pacific Islands (21 percent), and Japan (12 percent). Hispanic immigrants tended to be more consistently spread across Hispanic groups: Mexican Americans, who made up a large proportion of each generation, ranged between 62 and 70 percent; Cuban Americans between 2 and 6 percent; Puerto Ricans between 5 and 17 percent; and Hispanics from other countries between 16 and 23 percent. Conclusions were as follows:

Family Background

- Asian students were more likely than Hispanic students to come from two-parent families and to have at least one parent with a college degree.
- First-generation students in each racial/ethnic group were more likely to come from families that lived at or below the poverty level than their second- and third-generation counterparts.

Language Characteristics

- Similar proportions of all 1988 8th-grade Asians and Hispanics were categorized as being limited-English proficient (LEP) (6 and 8 percent, respectively). However, Hispanics from this cohort were more likely than their Asian peers to come from homes where a language other than English was spoken (66 versus 55 percent).
- Similar proportions of first-generation Asians and Hispanics were LEP students (12 and 15 percent, respectively), but second- and third-generation Hispanics were more likely to be LEP students than were their Asian counterparts (10 and 5 percent versus 2 and 1 percent, respectively).
- The likelihood that a student's family spoke a foreign language in the home decreased for each racial/ethnic group when a family had been in the United States for three or more generations. Nonetheless, the rate at which Hispanics from different generations spoke only English in the home was consistently lower than that of their Asian counterparts.

Mathematics, Reading, and Science Proficiency

- Among all 8th graders, Hispanics were more likely than Asians to be below the proficiency level on the NELS mathematics and science assessment (25 versus 9 percent in mathematics and 41 versus 25 percent in science). Students at the proficiency level in mathematics understand simple arithmetic operations on whole numbers—essentially single-step operations that rely on rote memory. Students at the proficiency level in science have an understanding of everyday science concepts, e.g., “common knowledge” that can be acquired in everyday life.

- ♦ The proportions of Asians and Hispanics who tested below the proficiency level on the NELS reading assessment, however, did not differ significantly (14 and 19 percent, respectively).
- ♦ The gap between the percentages of 1988 Asian and Hispanic 8th graders scoring below the proficiency level on the NELS mathematics assessment appeared within each of the three generations.

Parental Education Expectations

- ♦ Overall, the parents of 1988 Asian 8th graders were more likely to expect their children to earn at least a college degree than were the parents of Hispanic 8th graders (76 versus 47 percent).
- ♦ The parents of third-generation Asian students were less likely than the parents of first- and second-generation Asian students to expect their children to earn at least a bachelor’s degree (54 percent versus 81 and 86 percent, respectively). The parental expectations of Hispanic students did not differ significantly by generational status.

Postsecondary Enrollment

- ♦ As of 1994, among 1988 8th graders, Asian students were far more likely to have enrolled in postsecondary education in general and in a four-year institution in particular than their Hispanic counterparts.

First- and second-generation Asians in the 8th-grade class of 1988 were more likely than their third-generation counterparts to enroll in a postsecondary institution by 1994 (82, 91, and 63 percent, respectively). Enrollment rates for Hispanic students did not differ significantly by generation.

SOURCE: NCES 1999d.

and 40 percent of students in the 39 states participating in State NAEP were at or above the Proficient level in 2000. As shown in text table 1-3, thirty percent or more of public 8th-grade students scored at or above the Proficient level in Connecticut, Indiana, Kansas, Maine, Massachusetts, Minnesota, Montana, Nebraska, North Carolina, North Dakota, Ohio, Oregon, and Vermont, and 20 percent or less scored at that level in Alabama, Arkansas, California, Georgia, Hawaii, Louisiana, Mississippi, New Mexico, Oklahoma, South Carolina, Tennessee, and West Virginia. Between 1990 and 2000, the percentage of 8th graders performing at or above the Proficient level increased for 30 out of 31 jurisdictions participating in both years. Some states made more progress than others, however. For example, the percentage of public 8th-grade students scoring at the Proficient level tripled in North Carolina over this 10- year period (from 9 to 30 percent), while the percentage scoring at that level or higher in North Dakota remained stable (at about 30 percent).

Summary of NAEP Performance

Although science and mathematics achievement has improved since the late 1960s and early 1970s, the percentage of students scoring in mathematics at a level considered proficient is still only about a quarter at the 4th and 8th grades and one in six in 12th grade. The gap in math and science proficiency between whites and Asians/Pacific Islanders and their black, Hispanic, and American Indian/Alaskan Native counterparts is particularly wide, as is the gap between students from low- and high-income backgrounds (as measured by eligibility for the National School Lunch Program). Although the gap between the scores of white and black students narrowed through the 1980s, there is evidence that the gap is now widening. The range between high- and low-performing students within a particular grade is particularly wide, pointing to a challenge for programs designed to hold all students accountable to high standards.

International Comparisons of Mathematics and Science Achievement

Internationally, U.S. student relative performance becomes increasingly weaker at higher grade levels. On the Third International Mathematics and Science Study (TIMSS), 9-year-olds tended to score above the international average, 13-year-olds near the average, and 17-year-olds below it. Even the most advanced students at the end of secondary school performed poorly compared with students in other countries taking similar advanced mathematics and science courses. This section reviews the mathematics and science performance of U.S. students, drawing primarily on the 1995 TIMSS and the 1999 repeat of this study at the 8th-grade level (TIMSS-R).

The 1995 TIMSS included assessments of 4th- and 8th-grade students as well as students in their final year of secondary school. The study included several components: the assessments, analyses of curriculums for various countries, and an observational video study of mathematics instruction in 8th-grade classes in Germany, Japan, and the United States. In addition to updating the comparison of U.S. math and science achievement in the 8th grade, the design of TIMSS-R made it possible to track changes in achievement and certain background factors from the earlier TIMSS study between the 4th and 8th grades. TIMSS-R also indicates the pace of educational change across nations, informing expectations about what can be achieved (NCES 2000f).

Text table 1-3.
Percentage of students at or above the proficient level in NAEP mathematics by state for grade 8 public schools: 1990–2000

State	1990	1992	1996	2000
National	15[a]	20[a]	23[a]	26
Alabama[c]	9[b]	10[b]	12	16
Arizona[c]	13[b]	15[b]	18	21
Arkansas	9[b]	10[b]	13	14
California[c]	12[b]	16	17	18
Connecticut	22[b]	26[b]	31	34
Georgia	14[b]	13[b]	16	19
Hawaii	12[b]	14	16	16
Idaho[c]	18[b]	22[b]	—	27
Illinois[c]	15[b]	—	—	27
Indiana[c]	17[b]	20[b]	24[a]	31
Kansas[c]	—	—	—	34
Kentucky	10[b]	14[b]	16[a]	21
Louisiana	5[b]	7[b]	7[a]	12
Maine[c]	—	25[b]	31	32
Maryland	17[b]	20[b]	24	29
Massachusetts	—	23[b]	28[a]	32
Michigan[c]	16[b]	19[b]	28	28
Minnesota[c]	23[b]	31[b]	34[a]	40
Mississippi	—	6	7	8
Missouri	—	20	22	22
Montana[c]	27[b]	—	32	37
Nebraska	24[b]	26[a]	31	31
Nevada	—	—	—	20
New Mexico	10[b]	11	14	13
New York	15[b]	20[b]	22	26
North Carolina	9[b]	12[b]	20	30
North Dakota	27	29	33	31
Ohio	15[b]	18[b]	—	31
Oklahoma	13[b]	17	—	19
Oregon[c]	21[b]	—	26[a]	32
Rhode Island	15[b]	16[b]	20[a]	24
South Carolina	—	15	14[a]	18
Tennessee	—	12[b]	15	17
Texas	13[b]	18[b]	21	24
Utah	—	22[a]	24	26
Vermont[c]	—	—	27[a]	32
Virginia	17[b]	19[b]	21[a]	26
West Virginia	9[b]	10[b]	14[b]	18
Wyoming	19[b]	21[b]	22[a]	25

— = Jurisdiction did not participate.

[a]Significantly different from 2000 if only one jurisdiction or the nation is being examined.

[b]Significantly different from 2000 when examining only one jurisdiction and when using a multiple-comparison procedure based on all jurisdictions that participated both years.

[c]Indicates that the jurisdiction did not meet one or more of the guidelines for school participation.

NOTE: National results are based on the national sample, not on aggregated state assessment samples. Comparative performance results may be affected by changes in exclusion rates for students with disabilities and limited-English-proficient students in the National Assessment of Educational Progress samples.

SOURCE: National Center for Education Statistics, *The Nation's Report Card: Mathematics 2000*, NCES 2001-517 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2001e).

Science & Engineering Indicators – 2002

Achievement of 4th- and 8th-Grade American Students in 1995

U.S. 4th-grade students performed at competitive levels in 1995 in both science and mathematics.[5] In science, they scored well above the 26-country international overall average as well as the average in all content areas assessed: earth sciences, life sciences, physical sciences, and environmental issues/nature of science. Only students in South Korea scored at a higher level overall. The 4th-grade assessment in mathematics covered topics in whole numbers; fractions, and proportionality; measurement, estimation, and number sense; data representation, analysis, and probability; geometry; and patterns, functions, and relations. U.S. 4th-grade students scored above the international average on this assessment and performed comparatively well in all content areas except measurement (NCES 1997c).

As with 4th-grade students, the TIMSS science assessment taken by 8th-grade students covered earth and life sciences and environmental issues, but it also included content in physics and chemistry. With a mean score of 534 in science, 8th-grade U.S. students scored above the 41-country international average of 516. U.S. students performed at about the international average in chemistry and physics and above average in life sciences, earth sciences, and environmental issues (NCES 1996c).

Mathematics was the weaker area of 8th-grade achievement relative to the performance of students in other countries. The assessment covered fractions and number sense; geometry; algebra; data representation, analysis, and probability; measurement; and proportionality. Overall, 8th-grade U.S. students performed below the 41-country international overall average and at about the international average in algebra, data representation, and fractions and number sense. Performance in geometry, measurement, and proportionality was below the international average.

Change in Relative Performance Between 4th and 8th Grades

Change in the relative performance of U.S. students can be examined by comparing the average mathematics and science scores of U.S. 4th graders in 1995 and 8th graders in 1999 relative to the international average of the 17 nations that participated in 4th-grade TIMSS and 8th-grade TIMSS-R. (See sidebar, "How Comparisons Between 4th Graders in 1995 and 8th Graders in 1999 Are Made.") Figure 1-5 compares the average scores of the 17 nations between 4th-grade TIMSS and 8th-grade TIMSS-R with the international averages at both grades for each subject. The numbers shown in the figure are differences from the international average for the 17 nations. Nations are sorted into three groups: above the international average, similar to the international average, and below the international average.

[5]TIMSS results for 4th-, 8th-, and 12th-grade students have been widely reported, including in the previous volume of *S&E Indicators* (National Science Board 2000). TIMSS findings are outlined here in only general terms.

Figure 1-5.
Mathematics and science achievement for TIMSS-R 1999 countries/economies that participated in 1995 at both the 4th and 8th grades relative to the average across these locations

Mathematics

Country/economy	Fourth grade, 1995 Difference[a]
Singapore	73
South Korea	63
Japan	50
Hong Kong	40
Netherlands	32
Czech Republic	23
Slovenia	8
Hungary	4
United States	0
Australia	0
Italy	–7
Canada	–12
Latvia[b]	–18
England	–33
Cyprus	–42
New Zealand	–48
Iran	–130
Average	517

Country/economy	Eighth grade, 1999 Difference[a]
Singapore	80
South Korea	63
Hong Kong	58
Japan	55
Netherlands	16
Hungary	8
Canada	7
Slovenia	6
Australia	1
Czech Republic	–4
Latvia[b]	–19
United States	–22
England	–28
New Zealand	–33
Italy	–39
Cyprus	–48
Iran	–102
Average	524

Science

Country/economy	Fourth grade, 1995 Difference[a]
South Korea	62
Japan	39
United States	28
Australia	28
Czech Republic	18
Netherlands	17
England	14
Canada	12
Italy	10
Singapore	10
Slovenia	8
Hong Kong	–6
Hungary	–6
New Zealand	–9
Latvia[b]	–27
Cyprus	–64
Iran	–134
Average	514

Country/economy	Eighth grade, 1999 Difference[a]
Singapore	44
Hungary	28
Japan	25
South Korea	24
Netherlands	21
Australia	16
Czech Republic	15
England	14
Slovenia	9
Canada[c]	9
Hong Kong	5
United States	-9
New Zealand	–15
Latvia[b]	–21
Italy	–26
Cyprus	–64
Iran	–76
Average	524

Significantly higher than international average.
Does not differ significantly from international average.
Significantly lower than international average.

TIMSS = Third International Mathematics and Science study.

[a]Difference is calculated by subtracting international average of 17 locations from national average of each one.

[b]Only Latvian-speaking schools were tested.

[c]Shading may appear incorrect, but is statistically correct.

SOURCE: National Center for Education Statistics, *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999*, NCES 2001-028, Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000f.

Science & Engineering Indicators – 2002

The available evidence appears to confirm what had been suggested four years ago: the relative performance of U.S. students in mathematics and science is lower in 8th grade than in 4th grade among this group of nations. In mathematics, the U.S. 4th-grade score in 1995 was similar to the international average of the 17 nations in-common between the 4th-grade TIMSS and 8th-grade TIMSS-R. At the 8th-grade level in 1999, the U.S. average in mathematics was below the international average of the 17 nations. Because U.S. 4th graders performed at the international average in 1995 and U.S. 8th graders performed below the international average in 1999

How Comparisons Between 4th Graders in 1995 and 8th Graders in 1999 Are Made

The Third International Mathematics and Science Study (TIMSS) and other studies before it have suggested that the international performance of the United States relative to other nations appears lower at grade 8 in both mathematics and science than at grade 4. These statements were based on comparisons of the relative standing of 4th- and 8th-grade students in the same year, as opposed to a comparison of the growth in scores of cohorts of 4th graders over time. TIMSS-R provides the opportunity to examine how the relative achievement of U.S. 4th-grade students in 1995 compares with the achievement of 8th-grade students four years later in 1999. Direct comparisons between the 1995 4th-grade assessment and the 1999 8th-grade assessment are complicated by several factors, however. First, the 4th-grade and 8th-grade assessments include different test questions. By necessity, the type of mathematics and science items that can be asked of an 8th grader may be inappropriate for a 4th grader. Second, because mathematics and science differ in the two grades, the content areas assessed also differ. For example, geometry and physics at grade 4 are different from geometry and physics at grade 8. Without a sufficient set of in-common test items between the grade 4 and grade 8 assessments (which is the way that assessments are equated across ages and grades in the National Assessment of Educational Progress), it can be difficult to construct a reliable and meaningful scale on which to compare 1995 4th graders to 1999 8th graders. Thus, comparisons in this section between 4th and 8th grade are based on the performance relative to the international average of the 17 nations that participated in 4th-grade TIMSS and 8th-grade TIMSS-R.

SOURCE: NCES 2000f.

in mathematics, this suggests that the relative performance of the cohort of 1995 U.S. 4th graders in mathematics was lower relative to this group of nations four years later.

In science, the U.S. 4th-grade score in 1995 was above the international average of the 17 nations in-common between the 4th-grade TIMSS and 8th-grade TIMSS-R. At the 8th-grade level in 1999, the U.S. average in science was similar to the international average of the 17 nations. Thus, U.S. 4th graders performed above the international average in 1995 and U.S. 8th graders performed at a level similar to the international average in 1999 in science. As in mathematics, this suggests that the relative performance of the cohort of U.S. 4th graders in science was lower relative to this group of nations four years later. The data also suggest that, in science, the relative performance of the cohort of 1995 4th graders in Singapore and Hungary was higher relative to this group of nations in 1999; the relative performance of the cohort of 1995 4th graders in Italy and New Zealand was lower relative to this group of nations four years later; and the relative performance of the cohort of 1995 4th graders in the 12 other nations was unchanged relative to this group of nations four years later.

Mathematics and Science Achievement of 8th Graders in 1999

For most of the 23 nations that participated in 8th grade in both TIMSS and TIMSS-R, including the United States, there was little change in the mathematics and science average scores over the four-year period. There was no change in 8th-grade mathematics achievement between 1995 and 1999 in the United States and in 18 other nations. (See text table 1-4.) Three nations, Canada, Cyprus, and Latvia, showed an increase in overall mathematics achievement between 1995 and 1999. One nation, the Czech Republic, experienced a decrease in overall math achievement over the same period. In the United States and 17 other nations, there was no change in the science achievement score of 8th graders between 1995 and 1999; while it increased in four countries and decreased in one.

Students' Achievement in the Final Year of Secondary School

Students' performance in the final year of secondary school can be considered a measure of what students have learned over the course of their years in school. Assessments were conducted in 21 countries in 1995 to examine performance on the general knowledge of mathematics and science expected of all students and on more specialized content taught only in advanced courses.

Achievement on General Knowledge Assessments. The TIMSS general knowledge assessments were taken by all students in their last year of upper secondary education (12th grade in the United States), including those not taking advanced mathematics and science courses. The science assessment covered earth sciences/life sciences and physical sciences, topics covered in grade 9 in many other countries but not until grade 11 in U.S. schools. On the general science knowledge assessment, U.S. students scored 20 points below the 21-country international average, comparable to the performance of 7 other nations but below the performance of 11 nations participating in the assessment. Only 2 of the 21 countries, Cyprus and South Africa, performed at a significantly lower level than the United States. Countries performing similarly to the United States were Germany, the Russian Federation, France, the Czech Republic, Italy, and Hungary.

A curriculum analysis showed that the general mathematics assessment given to students in their last year of secondary education covered topics comparable to 7th-grade material internationally and 9th-grade material in the United States. Again, U.S. students scored below the international average, outperformed by 14 countries but scoring similarly to Italy,

Text table 1-4.
Comparison of 8th-grade mathematics and science achievement, by country or economy: 1995 and 1999

Country/economy	1995	1999	Difference[a]
Mathematics			
(Latvia)[b]	488	505	17*
Hong Kong	569	582	13
(Netherlands)	529	540	11
Canada	521	531	10*
(Lithuania)[c]	472	482	10
United States	**492**	**502**	**9**
Cyprus	468	476	9*
Belgium	550	558	8
South Korea	581	587	6
(Australia)	519	525	6
Hungary	527	532	5
Iran	418	422	4
Russian Federation	524	526	2
Slovak Republic	534	534	0
(Slovenia)	531	530	–1
(Romania)	474	472	–1
(England)	498	496	–1
Japan	581	579	–2
Singapore	609	604	–4
Italy	491	485	–6
New Zealand	501	491	–10
(Bulgaria)	527	511	–16
Czech Republic	546	520	–26*
International average	519	521	2
Science			
(Latvia)[b]	476	503	27*
(Lithuania)[c]	464	488	25*
Hong Kong	510	530	20
Canada	514	533	19*
Hungary	537	552	16*
(Australia)	527	540	14
Cyprus	452	460	8
Russian Federation	523	529	7
(England)	533	538	5
(Netherlands)	541	545	3
Slovak Republic	532	535	3
South Korea	546	549	3
United States	**513**	**515**	**2**
Belgium	533	535	2
(Romania)	471	472	1
Italy	497	498	1
New Zealand	511	510	–1
Japan	554	550	–5
(Slovenia)	541	533	–8
Singapore	580	568	–12
Iran	463	448	–15
Czech Republic	555	539	–16
(Bulgaria)	545	518	–27*
International average	518	521	3

*1999 average is significantly different from the 1995 average.

[a]Difference is calculated by subtracting 1995 score from 1999 score. Detail may not add to totals because of rounding.

[b]Only Latvian-speaking schools were tested.

[c]Lithuania tested the same cohorts of students as other locations, but later in 1999, at the beginning of the next school year.

NOTES: Parentheses indicate countries not meeting international sampling and/or other guidelines in 1995, 1999, or both years. The international average is derived from the national averages of 23 locations.Tests for significance take into account the standard error for the reported differences. Thus, a small difference between the 1995 and 1999 averages for one location may be significant, whereas a large difference for another location may not be significant. The 1995 scores are based on rescaled data.

SOURCE: National Center for Education Statistics, *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement From a U.S. Perspective, 1995 and 1999,* NCES 2001-028 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2000f).

Science & Engineering Indicators – 2002

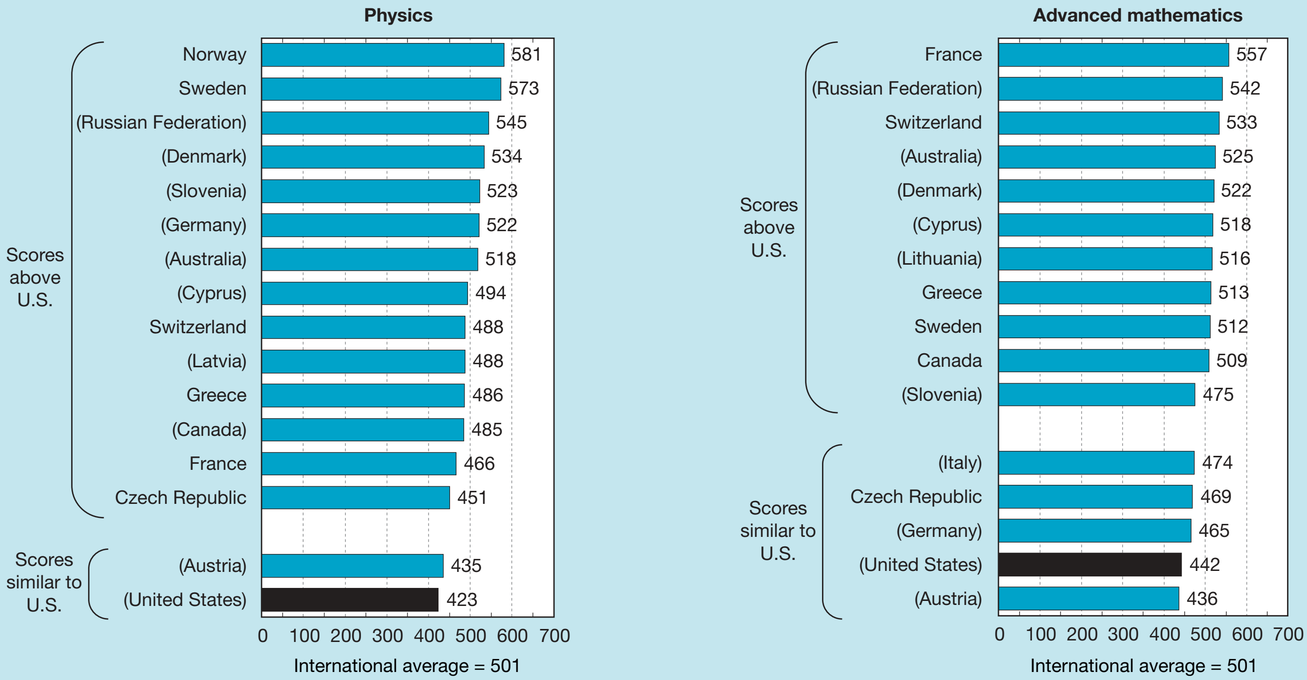
the Russian Federation, Lithuania, and the Czech Republic. As on the general science assessment, only Cyprus and South Africa performed at a lower level. These results suggest that students in the United States appear to be losing ground in mathematics and science to students in many other countries as they progress from elementary to middle to secondary school.

Achievement of Advanced Students. On advanced mathematics and science assessments, U.S. 12th grade students who had taken advanced coursework in these subjects performed poorly compared with their counterparts in other countries, even though U.S. students are less likely to have taken advanced courses than students at the end of secondary school in other countries. The TIMSS physics assessment was administered to students in other countries who were taking advanced science courses and to U.S. students who were taking or had taken physics I and II, advanced physics, or advanced placement (AP) physics (about 14 percent of the entire age cohort). The assessment covered mechanics and electricity/magnetism as well as particle, quantum, and other areas of modern physics. Compared with their counterparts in other countries, U.S. students performed below the international average of 16 countries on the physics assessment. (See figure 1-6.) The mean achievement scores of the United States (423) and Austria (435) were at the bottom of the international comparison (average = 501). Students in 14 other countries scored significantly higher than the United States. The subset of U.S. students taking or having taken AP physics scored 474 on the assessment, similar to scores of all advanced science students in nine other countries, and six countries scored higher (scores ranged from 518 to 581). Only Austria performed at a significantly lower level, with an average score of 435 (NCES 1998b). However, U.S. AP physics students represented a much smaller proportion of the age cohort in the United States (about 1 percent of the relevant age cohort) than did the students taking the advanced physics assessment in most of the other countries. For example, the physics assessment was taken by about 14 percent of the relevant age cohort in Canada, 20 percent in France, 8 percent in Germany, and 14 percent in Switzerland (NCES 1998b).

The advanced mathematics assessment was administered to students in other countries who were taking advanced mathematics courses and to U.S. students who were taking or had taken calculus, precalculus, or AP calculus (about 14 percent of the relevant cohort). One-quarter of the items tested calculus knowledge. Other topics included numbers, equations and functions, validation and structure, probability and statistics, and geometry.

The international average on the advanced mathematics assessment was 501. U.S. students, scoring 442, were outperformed by students in 11 nations, whose average scores ranged from 475 to 557. No nation performed significantly below the United States; Italy, the Czech Republic, Germany, and Austria performed at about the same level. (See figure 1-6.) U.S. students who had taken AP calculus had an average score of 513 and were exceeded only by students in France. Five nations scored significantly lower than the AP calculus students in the United States. Thus, the most advanced mathematics students in the United States (about 5 percent of the

Figure 1-6.
Average scale score on TIMSS physics and advanced mathematics assessment for students in final year of secondary school: 1994–95



TIMSS = Third International Mathematics and Science Study.

NOTE: Countries not meeting international guidelines are shown in parentheses.

SOURCE: I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith. *Mathematics and Science Achievement in the Final Year of Secondary School: IEA's Third International Mathematics Study (TIMSS)* (Chestnut Hill, MA: Boston College, TIMSS International Study Center: 1998).

Science & Engineering Indicators – 2002

relevant age cohort) performed similarly to 10 to 20 percent of the age cohort in most of the other countries. In other words, U.S. calculus students performed at a level similar to a number of other countries, although the percentage of the relevant age cohort (e.g., 17-year-olds) taking the test was significantly lower than in other countries.

Summary of International Assessment Results

Data from TIMSS and TIMSS-R show that U.S. students generally perform comparatively better in science than in mathematics; that students in the primary grades demonstrate the strongest performance, especially in science; that students in grade 8 show weaker performance; and that those in grade 12 show weaker performance still, relative to their counterparts in other countries. Furthermore, while the United States tends to have fewer young people taking advanced math and science courses, students that do take them score lower on assessments of advanced mathematics and physics than do students who take advanced courses in other countries.

Science and Mathematics Coursework

Concerns about both the content and lack of focus of the U.S. mathematics and science curriculum, both as it is stated in state-level curricular frameworks and how it is implemented in the classroom, have appeared in major studies since the early 1980s (NCES 2000d). In 1983, the National Commission on Excellence in Education concluded that the curricular "smorgasbord" then offered in American schools combined with extensive student choice explained a great deal of the low performance of U.S. students (National Commission on Excellence in Education 1983).

Since the publication of *A Nation At Risk* nearly 20 years ago, most states have increased the number of mathematics and science courses required for high school graduation as a way to address this concern. A number of states and districts have also implemented "systemic" or "standards-based" reform efforts in order to align curricular content with student testing and teacher professional development. (See sidebar, "The NGA Perspective on Systemic, Standards-Based Reform"). This section examines state-level changes in curricular requirements, as well as changes in student course-taking patterns. While the impact of these changes on student performance is uncertain, it is clear that more students are taking advanced mathematics and science courses than they were two decades ago.

Changes in State-Level Graduation Requirements

As of 2000, 25 states required at least 2.5 years of math and 20 states required 2.5 years of science; in 1987, only 12 states required that many courses in math and only 6 states required that many courses in science. A survey of states conducted by the Council of Chief State School Officers (CCSSO) in 2000 showed the following state totals for required credits in mathematics and science (CCSSO 2000a):

- Twenty-one states required between 2.5 and 3.5 credits of mathematics and four states required four credits.
- Sixteen states required between 2.5 and 3.5 credits of science and four states required four credits.
- Five states left graduation requirements to local districts.

The National Education Commission on Time and Learning (NECTL) cites research indicating positive effects of strengthened graduation requirements. As schools offered more academic courses, particularly in mathematics and science, more students, including minority and at-risk students, actually enrolled in the courses (National Education Commission on Time and Learning 1994). Data from high school transcripts collected by NCES support this finding. Students took more advanced science and mathematics courses in 1998 than did students who graduated in the early 1980s (NCES 2001c). In 1998, almost all graduating seniors (93 percent) had taken biology, and more than one-half (60 percent) had taken chemistry. (See figure 1-7 and text table 1-5.) In comparison, 77 percent of 1982 seniors had completed biology and 32 percent had completed chemistry. In the class of 1998, more than one-quarter (29 percent) of graduates had completed physics compared with 15 percent of 1982 graduates. Participation rates in AP or honors science courses are considerably lower: 16 percent for biology, 5 percent for chemistry, and 3 percent for physics (NCES 2001c).

In 1998, more graduating students had taken advanced mathematics courses than did their counterparts in the early 1980s (see figure 1-7). In 1998, 62 percent of students had taken algebra II compared with 40 percent in 1982. The 1998 participation rates for geometry and calculus were 75 percent and 11 percent, respectively. Corresponding figures for 1982 were 47 percent in geometry and 5 percent in calculus. The percentage of graduates taking AP calculus rose from 1.6 to 6.7 percent over the same period (NCES 2001c).

From 1982 to 1998, there was a corresponding decrease in the percentage of graduates who took lower level mathematics courses. For example, the average number of Carnegie units in mathematics earned by graduates increased from 2.6 to 3.4 between 1982 and 1998, but the average number of units earned in courses at a lower level than algebra declined from 0.90 to 0.67 (NCES 2001c).[6]

The NGA Perspective on Systemic, Standards-Based Reform

According to the National Governors Association (NGA), systemic, standards-based education reform centers on the premise that all students can achieve at high levels and is based on rigorous academic standards for student learning. This is a comprehensive approach that aligns numerous educational policies, practices, and strategies, including:

- **Content standards**—standards that reflect subject-matter benchmarks;
- **Performance standards**—standards that clarify the benchmarks to be obtained;
- **Student assessments**—tests that measure student performance against content and performance standards;
- **An accountability system**—a system that monitors student and school performance;
- **Teacher preparation**—licensure requirements that permit someone to teach;
- **Professional teacher development**—activities that provide continued learning opportunities;
- **A governance structure**—a structure that defines how decisions are made; and
- **Public support**—tools that help the public understand the education reforms.

The premise underlying systemic, standards-based reform is that rigorous academic standards make achievement expectations clear. In principle, standards detail what students should know and be able to do in various subjects at each grade level or at specified benchmark grade levels. High-quality assessments can then measure student progress toward meeting the standards and provide parents, teachers, and policymakers with information about student progress. A strong accountability system is one that holds schools, educators, and students accountable for making sure students achieve the established standards. A solid system also recognizes high-performing or improving students and schools for their success and provides assistance and guidance to struggling students and schools.

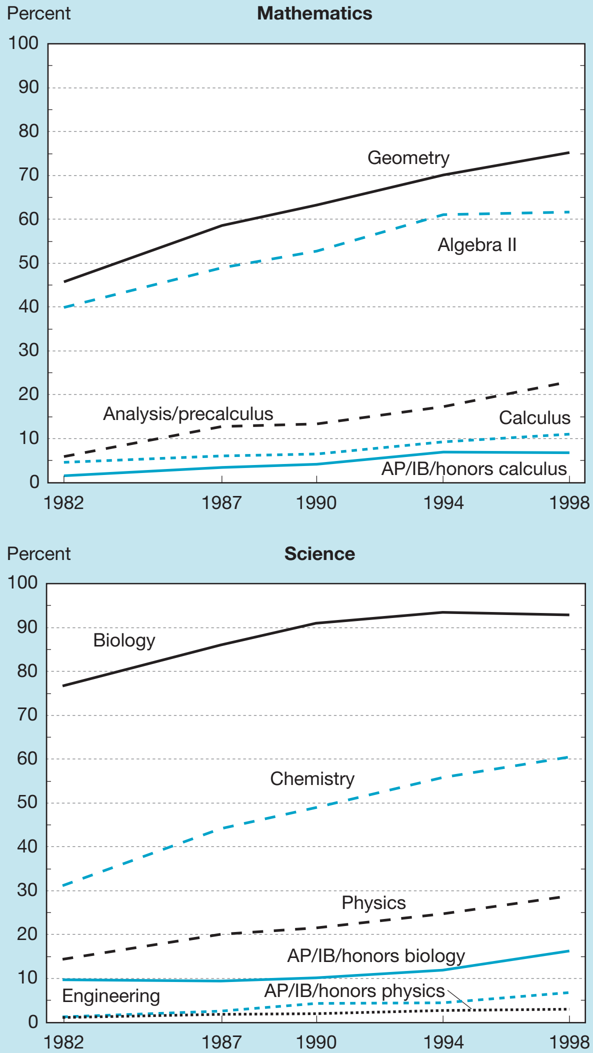
SOURCE: National Governor's Association Center for Best Practices, n.d.

Differences in Course Participation by Sex

Given the established association between courses taken in high school and later educational outcomes (J. Smith 1996; Sells 1978), the lower representation of females throughout the science, mathematics, and engineering pipeline has been

[6] The Carnegie unit is a standard of measurement that represents one unit of credit for the completion of a one-year course.

Figure 1-7.
Percentage of high school graduates who took selected mathematics and science courses: 1982, 1987, 1990, 1994, and 1998



AP = Advanced Placement; IB = International Baccalaureate

SOURCE: National Center for Education Statistics, *The 1998 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1998, 1994, 1990, 1987, and 1982 High School Graduates,* NCES 2001-498, Washington DC: U.S. Department of Education, Office of Educational Research and Improvement: 2001a.

Science & Engineering Indicators – 2002

a cause for concern. Therefore, there has long been an interest in tracking sex differences in the patterns of advanced mathematics and science courses taken in high school.

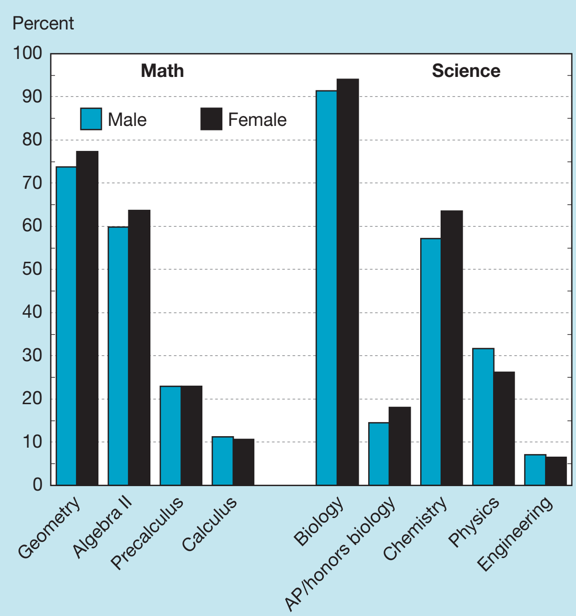
Both female and male students are following a more rigorous curriculum than they were two decades ago, and female graduates in 1998 were more likely than males (58 versus 53 percent) to have completed the "New Basics" curriculum, composed of four units of English and three units each of science, social studies, and mathematics, as recommended in *A Nation At Risk* (NCES 2000b). Comparison of the transcripts of high school graduates indicates that female and male students have broadly similar coursetaking patterns, although there are some differences. Female students are as likely as males to take advanced math and science courses but are more likely to study a foreign language. Between 1982 and 1992, the percentage of both female and male graduates who took advanced mathematics and science courses in high school increased, although for many subjects parity between the sexes had been attained by 1982 (NCES 2000b). In the class of 1998, females were less likely than males to take remedial mathematics in high school but at least as likely as their male peers to take upper level mathematics courses such as algebra II, trigonometry, precalculus, and calculus. (See figure 1-8 and text table 1-5.) With respect to science, females were more likely than males to take biology and chemistry. Females have continued, however, to be less likely than males to take physics (NCES 2000b).

Research has shown that once females begin science courses, they are taught similar amounts of science and receive grades similar to (or better than) those of their male counterparts (Hanson, Schaub, and Baker 1996; Baker and Jones 1993; DeBoer 1984).

Differences in Course Participation by Race/Ethnicity

Students from racial/ethnic groups that are typically underrepresented in science have made substantial gains in both the total number of academic courses taken in high school and in the number of advanced mathematics and science

Figure 1-8.
Percentage of 1998 high school graduates who took selected mathematics and science courses in high school, by sex



SOURCE: National Center for Education Statistics, *Trends in Educational Equity of Girls and Women*, NCES 2000-030 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000h).

Science & Engineering Indicators – 2002

Text table 1-5.
High school graduates who completed selected mathematics and science courses in high school, by sex and race/ethnicity
(percentages)

Courses (Carnegie units)	1982	1987	1990	1994	1998 Total	1998 Male	1998 Female	1998 Race/ethnicity: White	Black	Hispanic	Asian/ Pacific Islander	American Indian/Alaskan Native
Mathematics[a]												
Any mathematics (1.0)	98.5	99.0	99.9	99.8	99.8	99.8	99.8	99.8	99.9	99.8	100.0	99.7
Algebra I (1.0)[b]	55.2	58.8	63.7	65.8	62.8	62.0	63.6	63.5	62.3	61.4	56.8	63.3
Geometry (1.0)	47.1	58.6	63.2	70.0	75.1	73.7	77.3	77.7	72.5	62.3	75.9	57.2
Algebra II (0.5)[c]	39.9	49.0	52.8	61.1	61.7	59.8	63.7	64.6	55.6	48.3	70.1	46.6
Trigonometry (0.5)	8.1	11.5	9.6	11.7	8.9	8.2	9.7	10.0	4.8	5.6	11.7	5.5
Analysis/precalculus (0.5)	6.2	12.8	13.3	17.3	23.1	23.1	22.8	25.0	13.8	15.3	41.3	16.4
Statistics/probability (0.5)	1.0	1.1	1.0	2.0	3.7	3.4	3.9	4.3	2.1	1.7	3.8	3.7
Calculus (1.0)	5.0	6.1	6.5	9.3	11.0	11.2	10.6	12.1	6.6	6.2	18.4	6.2
AP/IB calculus (1.0)	1.6	3.4	4.1	7.0	6.7	7.3	6.4	7.5	3.4	3.7	13.4	0.6
Science												
Any science (1.0)	96.4	97.8	99.3	99.5	99.5	99.5	99.6	99.5	99.3	99.3	99.4	99.4
Biology (1.0)	77.4	86.0	91.0	93.2	92.7	91.4	94.1	93.7	92.8	86.5	92.9	91.3
AP/IB honors biology (1.0)	10.0	9.4	10.1	11.9	16.2	14.5	18.0	16.7	15.4	12.6	22.2	6.0
Chemistry (1.0)	32.1	44.2	48.9	55.8	60.4	57.1	63.5	63.2	54.3	46.1	72.4	46.9
AP/IB honors chemistry (1.0)	3.0	3.5	3.5	3.9	4.7	4.9	4.7	4.8	3.5	4.0	10.9	0.9
Physics (1.0)	15.0	20.0	21.6	24.5	28.8	31.7	26.2	30.7	21.4	18.9	46.4	16.2
AP/IB honors physics (1.0)	1.2	1.8	2.0	2.7	3.0	4.0	2.1	3.0	2.1	2.1	7.6	0.9
Engineering (1.0)	1.2	2.6	4.2	4.5	6.7	7.1	6.5	7.9	4.8	2.3	5.2	9.6
Astronomy (0.5)	1.2	1.0	1.2	1.7	1.9	2.4	1.5	2.4	0.9	0.8	1.0	2.1
Geology/earth science (0.5)	13.6	13.4	24.7	22.9	20.7	21.5	20.1	21.5	24.2	15.9	9.5	21.7
Biology and chemistry (2.0)	29.3	41.4	47.5	53.7	59.0	55.4	62.3	62.0	53.0	43.7	69.5	43.2
Biology, chemistry, and physics (3.0)	11.2	16.6	18.8	21.4	25.4	27.4	23.7	27.6	17.4	15.9	40.2	14.2

AP = Advanced placement; IB = International Baccalaureate

[a]Data include only percentage of students who earned credit in each course while in high school and do not count those students who took these courses before entering high school. Many students now take algebra I in 8th grade.

[b]Excludes prealgebra.

[c]Includes algebra II/trigonometry and algebra II/geometry.

NOTE: A Carnegie unit is a standard of measurement that represents one unit of credit for the completion of a one-year course.

SOURCES: National Center for Education Statistics, *Digest of Education Statistics 2000*, table 140, NCES 2001-034, (Washington DC: U.S. Department of Education, Office of Educational Research and Improvement, 2001b).

Science & Engineering Indicators – 2002

courses taken, although the range in coursetaking patterns remains wide. The emphasis on academic coursetaking is reflected by the increase in the percentage of high school graduates in all racial/ethnic groups taking the “New Basics” curriculum. The proportion of 1998 high school graduates who took this core curriculum ranged from about 40 percent for Hispanics and American Indians/Alaskan Natives, to 56 percent for blacks and whites, to 66 percent for Asians/Pacific Islanders. This is a substantial increase from 1982, when only 14 percent of graduates took this stringent curriculum (NCES 2001c).

Students in all racial and ethnic groups are taking more advanced mathematics and science courses, although black, Hispanic, and American Indian/Alaskan Native graduates still lag behind their Asian/Pacific Islander and white counterparts in advanced mathematics and science coursetaking. For example, the percentage of graduates in the class of 1998 who had taken algebra II ranged from 47 percent of American Indians/ Alaskan Natives to 70 percent of Asians/Pacific Islanders. Percentages for white, black, and Hispanic graduates were 65, 56, and 48 percent, respectively. (See text table 1-5.) Furthermore, Asians/Pacific Islanders were a third more likely than whites to take calculus (18 versus 12 percent) and approximately three times more likely than blacks, Hispanics, and American Indians/Alaskan Natives (about 6 percent each). Also, although 46 percent of Asian/Pacific Islander graduates took physics in high school, blacks, Hispanics, and American Indians/Alaskan Natives were less than half as likely to do so (NCES 2001c). From a coursetaking perspective at least, it appears that all racial and ethnic groups are better prepared for college today than they were in the early 1980s, although blacks, Hispanics, and American Indians/Alaskan Natives are less prepared than their Asian/Pacific Islander and white peers.

Both prior achievement and peer choices appear to strongly influence coursetaking in high school. Although some researchers have found that minority and low socioeconomic status (SES) students are more likely to be assigned to lower curriculum tracks in high school, even after ability is held constant (Oakes 1985; Rosenbaum 1980, 1976), others have found that verbal achievement scores and the expectations and guidance of others (parents, teachers, guidance counselors, and peers) are influenced by race and SES and that these mediating variables then influence track placement (Cicourel and Kituse 1963; Rosenbaum 1976; Erickson 1975; Heyns 1974). Fordham and Ogbu (1986) argue that one major reason black students do poorly in school is that they experience inordinate ambivalence and affective dissonance with regard to academic effort and success. They argue that because of these social pressures, many black students who are academically able do not muster the necessary perseverance in their schoolwork. (See sidebar, "Advanced Placement Test Results.")

Impact of Coursetaking on Student Learning

On balance, it appears to be too early to draw general conclusions about the quality of either the new courses required in state-level curriculums or the advanced mathematics and science courses that more and more students are taking. Studies of "dilution" of course content are mixed and not uniform across all students. Moreover, many of these studies were conducted in only a handful of states and school districts and for only a handful of courses, with the earlier studies having

Advanced Placement Test Results in Urban Schools

A recent study by the Council of the Great City Schools (GCS), titled *Advancing Excellence in Urban Schools: A Report on Advanced Placement Examinations in the Great City Schools,* examined advanced placement (AP) coursetaking patterns and subject test results in America's urban schools. The council conducted the analysis in collaboration with the College Board, which offers AP courses and exams in 33 subjects. Findings were based on approximately 38,000 AP test results from 58 GCS districts in the spring of 1999. Results showed that:

- Mean AP test scores for GCS students were more likely to be below the 3.0 needed to earn college credit than were the scores of students nationally, whose mean AP test scores were slightly above 3.0.
- African American GCS students were more likely to take AP exams in English language, biology, and English literature; they were least likely to take calculus BC and physics C (electricity and magnetism) exams.
- Hispanic GCS students were most likely to take English literature, calculus AB, and physics B exams; they were least likely to take calculus BC and computer science A exams.
- Asian American GCS students were most likely to take calculus BC and physics C (electricity and magnetism) exams; they were least likely to take AP exams in English language and English literature.
- GCS students posted their highest average AP scores in calculus (3.3) and lowest average scores in physics and chemistry (2.2).
- GCS students who had taken more core courses outscored those who had taken fewer core courses. For this study "core" academic preparation was defined as the courses in each content area that many college admissions officers use to determine proper academic preparation for an incoming first-year college student. For example, the core includes three years of mathematics, such as one year credit each for Algebra 1, Algebra 2, and Geometry and one-half year credit each for Trigonometry, Calculus (not Pre-calculus), other mathematics courses beyond Algebra 2, and Computer Mathematics/Computer Science. The core also includes three years of science reasoning, such as one year credit each for General/Physical/Earth Science, Biology, Chemistry, and Physics.
- Nationally, students with core or more academic preparation attained higher AP subject test scores than GCS students with similar academic preparation. African American test-takers in the GCS were less likely to have taken core courses in Biology and Chemistry than all other racial groups in the GCS. Hispanic test-takers in the GCS were more likely to have taken core courses in Chemistry than all other racial groups in the GCS.
- AP scores nationally and in GCS were strongly related to family income. Students nationally outscore their GCS counterparts at each household income bracket. The only GCS students who had average scores of 3.0 or above in any AP subject were those with household incomes greater than $80,000.
- White students were likely to outperform other students nationally and in GCS. White students in the national sample had higher AP subject test scores than their white counterparts in the GCS. African American students in the GCS scored lower than their counterparts in the national sample.

The Council of the Great City Schools consists of 57 urban school districts (out of 16,411 in the United States) and enrolls about 14 percent of the students attending U.S. public schools. These districts serve a larger proportion of minority students than the national average (73 percent of students were black or Hispanic in 1999), and the majority are poor (63 percent are free-lunch eligible compared with 35 percent of students nationally).

SOURCE: Council of the Great City Schools (CGCS) and the College Board. 2001. *Advancing Excellence in Urban Schools: A Report On Advanced Placement Examinations in the Great City Schools.* Washington, DC <http://www.cgcs.org/reports/home/ap_1999.htm> and Key Facts: 1997–98 Data About Council Member Districts <http://www.cgcs.org/reports/data/index.cfm>.

been conducted not long after the increased requirements were enforced. Thus, there may have been little opportunity for revisions and improvement.

Several studies point to possible negative effects of stronger coursetaking requirements. For example, minority and at-risk students failed more courses than they did before stronger mandates were put into practice (NECTL 1994). Opinions differ on the quality of the additional courses taken, especially those taken by low-achieving students. There has been particular concern about the quality of new mathematics courses designed for low achievers, who, under a traditional curriculum, would have taken general or basic mathematics. Research suggests that implementation of state-level mandates for stronger coursetaking requirements varies greatly across districts and schools. Studying 18 high schools in 12 districts in 6 states, Porter, Smithson, and Osthoff (1994) found some schools pushing students into demanding content in higher level course while others did not. Furthermore, Gamoran (1997) found that bridging courses, those designed to prepare lower achieving students for college-preparatory courses, achieved some success in improving student achievement. Research in this area is inadequate, however, for evaluating whether or not the increase in state-level curricular requirements have changed the level of difficulty or quality of mathematics and science courses offered to students.

Additional studies accessing the content of the mathematics curriculum, as well the quality of 8th grade mathematics instruction, are described in the section on Curriculum and Instruction. Strengthening course-taking requirements is only one component of most educational reform strategies, however. The next section examines states' attempts to implement state-wide curricular frameworks, as well as assessments of the underlying content.

Content Standards and Statewide Assessments

In the 1980s, most states approved policies aimed at improving the quality of K–12 education, implementing state-wide curriculum guidelines and frameworks as well as assessments. At present, half of the states require students to pass some form of exit examination to graduate from high school, and others report developing such tests (CCSSO 2000a). Underlying this reform agenda is the assumption that these standards and assessments will lead to higher student achievement. However, assessments and standards are not always tightly linked, and the implied performance incentives for students, teachers, and administrators vary across states. Furthermore, there is concern that some state-level assessments focus too much on facts, even though the associated standards call for complex scientific inquiry. This section reviews the national data available concerning the implementation of standards and assessments across states. Particular attention is paid to the alignment of these new standards and assessments to student achievement by reviewing recent research in this area.

Adoption of Content Standards

State-level content standards are typically intended to provide the basis for state and local decisions on curriculum, texts, instructional materials, student assessments, teacher preparation and professional development, and other components of programs of instruction (CCSSO 2000a). CCSSO reported that, by 2000, 49 states had established content standards in mathematics and 46 states had established standards in science (CCSSO 2000a). Teachers remain concerned, however, that standards do not always provide clear guidance regarding the goals of instruction and that schools do not yet have access to top-quality curriculum materials aligned with the standards (Achieve 2000). The next section highlights some issues regarding the degree to which states require or facilitate the alignment between instructional materials and standards.

Statewide Policies on Textbooks and Standards

One way that states can influence the implementation of mathematics and science standards is to select or recommend textbooks and curriculum materials for schools that are aligned with their standards. Fewer than half of the states, however, mandate or recommend particular textbooks and curriculum materials. The Council of Chief State Officers reported that a total of 21 states had a state policy regarding textbooks and curriculum materials for classrooms, as of spring 2000 (CCSSO 2000a). Among the total, 11 have a state policy defining state selection of textbooks and materials to be used and another 10 recommend texts or materials to the local districts. In 2000, 20 of the 21 states with a textbook policy use their state content standards to select or recommend curriculum materials, the same as in 1998.

Some examples of state policies on textbooks include California, where content standards and frameworks are used to select the materials that will be adopted by the State Board of Education and recommended to school districts and Tennessee, where the state adopts an approved list of curricular materials from which local schools boards may then choose and receive state funds. These policies contrast with those of Alaska and New Jersey, where textbook selection decisions are left up to the local boards. As noted above, most states do not have a statewide policy on aligning textbooks and standards (CCSSO 2000a). (See sidebar, "States Band Together to Create a Market for Standards-Based Materials").

State Assessment Programs in Mathematics and Science

Nearly all states conduct statewide assessments in mathematics, although the grades assessed and the type of test vary widely. Results of the most recent CCSSO Annual Survey of State Student Assessment Programs (for the 1998/99 school year) show that 48 states have a statewide program in one or more subjects (CCSSO 2000a). Although many states have administered statewide assessments of student learning since the 1970s, additional states approved policies requiring

States Band Together to Create a Market for Standards-Based Materials

Although some states set statewide curriculums and approve textbooks for statewide use, the development and use of curricular materials is typically the responsibility of a local school district or a school. Because most of the materials used in schools come from commercial publishers, obtaining curricular materials that are well aligned to a school's curriculum is a challenge. One way in which states can influence the development of standards-based materials is by banding together to create a larger market. One example of this is the Mathematics Achievement Partnership (MAP), a consortium of 11 states brought together by Achieve, Inc., an independent, bipartisan, nonprofit organization created by governors and corporate leaders to help raise standards and performance in American schools. MAP is developing a common set of expectations for middle school mathematics, and participating states will administer an 8th-grade assessment based on these expectations. Although the partnership plans to develop materials, it may also create enough of a market to encourage publishers to align their materials with the expectations the states have jointly produced.

SOURCE: Achieve 2000.

statewide student testing throughout the 1980s and 1990s, and the number of subjects and grades to be assessed increased. Important factors in the growth of state policies are greater interest in accountability tied to student performance; needs for assessing learning growth related to policies and programs; and federally funded programs linked to state assessments of learning, such as Title I and the Individuals with Disabilities Education Act (CCSSO 2000a).

In academic year 1998/99, 48 states required statewide assessments in mathematics, up from 34 states in 1984 and 45 states in 1994; 23 states started at grade 3 or earlier and nearly all states assessed at least one grade near the end of high school. Thirty-one states administered norm-referenced tests and 40 administered criterion-referenced tests (CRT).[7] Twenty-five states administered both, depending on the grade and the purpose of the assessments. All states had multiple-choice items on their tests, although 26 states included short-answer questions and 27 included extended-response items as well. Only two states included individual performance assessments as part of their testing program, and another two included reviews of portfolios or learning records.

Fewer states have statewide assessment programs in science; there were 33 in 1998/99, up from 13 in 1983/84 and 30 in 1993/94. Among these states, 19 administer norm-referenced tests, 23 administer criterion-referenced tests, and 9 use some combination of both at different grades. As with mathematics, multiple-choice items are included on each state's tests, although 12 states include short-answer questions, 12 states include extended-response items, and 6 states included some means of performance assessment (CCSSO 2000a).

Public Support for Standards and Testing

Although some states have recently delayed the introduction of high-stakes tests (i.e., tests that students must pass to either graduate or advance a grade), public support for standards and testing remains strong. In September 2000, the nonprofit, nonpartisan research organization Public Agenda conducted a national survey of parents to gauge whether there had been backlash against standards. The study contained both a nationally representative sample of parents and a sample of parents in districts that are actually implementing higher academic standards (Public Agenda 2000).[8]

This study found that only 2 percent of parents who knew that their school district was implementing higher academic standards wanted to return to previous practice. Fifty-three percent wanted to continue with the effort as planned, and one in three (34 percent) wanted to continue with some adjustments. Additional interviews in Boston, Chicago, Cleveland, Los Angeles, and New York (five cities with highly visible efforts to raise standards) returned similar results. More than 8 in 10 (82 percent) parents who knew their school district was implementing higher standards believed their schools had, in fact, been "careful and reasonable" in putting the new standards in place.

Relatively few parents in the study said that their child's school requires them to take too many standardized tests to the detriment of other important learning (11 percent), that teachers in their child's school "focus so much on preparing for standardized tests that real learning is neglected" (18 percent), or that their child receives too much homework (10 percent). Furthermore, three out of four parents agreed that "students pay more attention and study harder if they know they must pass a test to get promoted or to graduate," and a similar proportion agreed that "requiring schools to publicize their standardized test scores is a wake-up call and a good way to hold schools accountable."

Parents did not feel, however, that promotion or graduation decisions should be based on a single test. Almost 8 in 10 (78 percent) agreed that "it's wrong to use the results of just one test to decide whether a student gets promoted or graduates." (See sidebar, "Employer and College Professor Perceptions of How Well Young People Are Prepared for Work and College.")

[7]Norm-referenced tests compare the scores of test takers with those of a representative, usually national, sample of students who have taken the test previously. Criterion-referenced tests (CRTs) are designed to indicate the degree of mastery of skills that have been taught. CRTs report how well students are doing relative to a predetermined performance level on a specified set of educational goals or outcomes included in the school, district, or state curriculum (Bond 1996).

[8]This survey was based on a national random sample telephone survey of 803 parents of public school students in grades K–12. The margin of error for the national sample is ±3 percentage points. Oversamples were conducted with at least 200 additional parents of students who attend public schools in Boston, Chicago, Cleveland, Los Angeles, and New York, where the margin of error for each oversample city is ±7 percentage points.

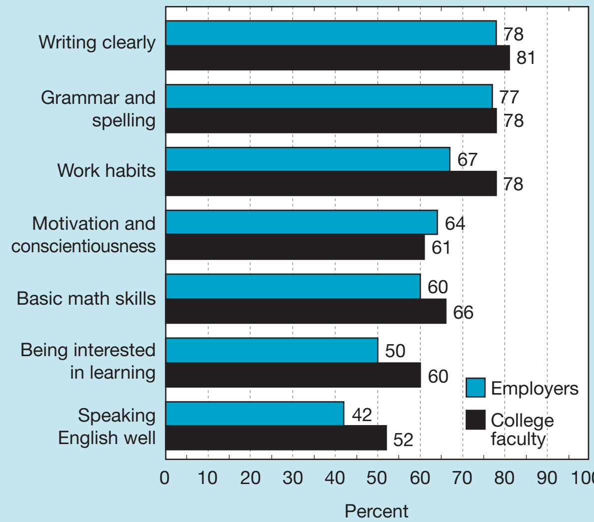
Employer and College Professor Perceptions of How Well Young People Are Prepared for Work and College

Employers and professors are far more disapproving than parents or teachers of how well young people are prepared for college and work, and very large majorities continue to voice significant dissatisfaction about students' basic skills. This finding comes from a recent "Reality Check" Survey by Public Agenda, a nonprofit, nonpartisan research group. (See figure 1-9.) This survey tracks whether efforts to set high education standards have made a difference by interviewing the students and teachers in public schools, the parents of those students, and the employers and college professors who deal with recent graduates. Employers and college professors were asked how they would rate recent job applicants/freshmen and sophomores across different topics, including clear writing, work habits, motivation and conscientiousness, and basic math skills. About two-thirds of professors found the basic math skills of recent freshmen and sophomores to be only "fair" or "poor." About 80 percent stated that student ability to write clearly was only "fair" or "poor." These results point to the continuing gap between student skill level and preparation for college and college professor views of the adequacy of that preparation. Results were similar for employers regarding recent job applicants. Both professors and employers support testing, with employers more likely to support testing of basic skills and professors more likely to support a test "showing that they (high school graduates) have learned at higher levels." Less than 10 percent of both groups reported thinking that "requiring kids to pass a test" before receiving a high school diploma is a "bad idea." (See figure 1-10.)

The responses above were derived from telephone interviews conducted in November and December 2000 with national random samples of 251 employers who make hiring decisions for employees recently out of high school or college and 254 professors at two- and four-year colleges who taught freshmen or sophomores in the last two years. The margin of error for employers and college professors is ±6 percentage points.

SOURCE: Public Agenda Online 2001.

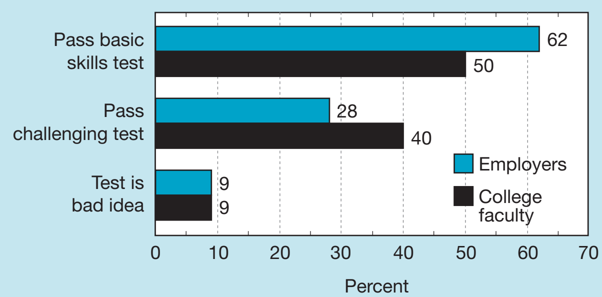
Figure 1-9.
Percentage of employers and college faculty who rated job applicants/freshman and sophomore students as "fair" or "poor" on various activities: 2000



SOURCE: Public Agenda, *Reality Check 2001,* http://www.publicagenda.org/specials/rc2001/reality6.htm. Accessed 8/20/2001.

Science & Engineering Indicators – 2002

Figure 1-10.
Employee/faculty support for high stakes testing: 2000[a]



[a]Data are based on responses to the following question: Before students are awarded a high school diploma, would you want the school district where you work/teach to require students to pass a basic skills test in reading, writing, and math; pass a more challenging test showing they have learned at higher levels; or do you think requiring kids to pass a test is a bad idea?

SOURCE: Public Agenda, *Reality Check 2001,* http://www.publicagenda.org/specials/rc2001/reality6.htm. Accessed 8/20/2001.

Science & Engineering Indicators – 2002

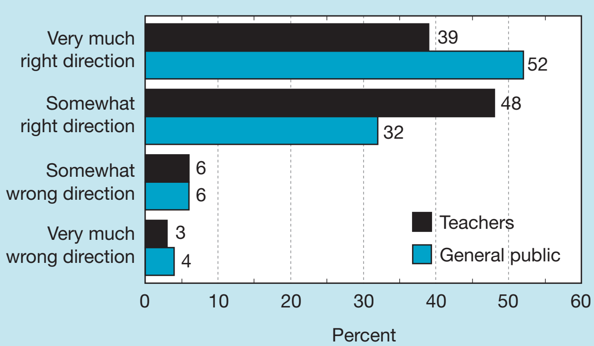
Attitudes of Teachers on Academic Standards and State Testing

The success of reforms based on state-wide standards and high-stakes testing rests to a large extent on the commitment of teachers to align their teaching to the standards. In September 2000, *Education Week* sponsored a survey of public school teachers to find out whether they thought that the academic standards being put into place are helping them teach children better. Specifically, teachers were asked whether they find the standards useful or a hindrance, whether they have enough time and resources to understand the standards and integrate them successfully into their lesson plans, and whether they feel the current tests are helping to assess student abilities or are taking up too much classroom time. Finally, teachers were asked whether they believe students are learning more (Belden, Russonello, and Stewart Research and Communications 2000). The findings of this survey are summarized below.

How Do Teachers View Academic Standards?

Public school teachers generally support the movement to raise standards, but they are less supportive than the general public. (See figure 1-11.) Nearly 9 out of 10 teachers said that raising academic standards for what students should learn each year and before they graduate is a move in the right direction, 39 percent said it is very much in the right direction, and 48 percent said it is somewhat in the right direction. Nearly three-quarters of teachers said that the academic standards for students in the state where they live are "about right," 5 percent said the standards are too high, and only 7 percent said that standards are too low. These findings were similar for mathematics and science teachers.

Figure 1-11.
Opinion of teachers and general public on move to raise academic standards: 2000



NOTE: Data are based on answers to the following: Many states are adopting new standards for what students should learn each year before they graduate. In general, do you believe the emphasis on raising academic standards is a move in the right or in the wrong direction?

SOURCE: Belden, Russonello, and Stewart Research and Communications, *Making the Grade: Teachers' Attitudes Toward Academic Standards and State Testing: Findings of National Survey of Public School Teachers for Education Week* (Washington, DC: 2000).

Science & Engineering Indicators – 2002

A larger proportion of the general public supports the direction of the standards movement, and these supporters are more likely than teachers to say that the current standards are too low. On a national survey conducted in August 2000, 52 percent of Americans believed the movement to adopt new standards is very much in the right direction, and 32 percent believed that it is somewhat in the right direction (Public Agenda 2000). Only 42 percent of the general public said that the current standards are about right, 5 percent said they are too high, and 47 percent said they are too low.

Do Teachers Believe That Their Students Are Meeting Standards?

Nearly two-thirds of public school teachers said that all or most of their students are currently meeting the standards for their grade, and only 8 percent said that a few or none of their students are meeting standards. Suburban teachers, teachers in schools where fewer than 10 percent of students are receiving free lunch, and teachers in states with exit examinations were more likely to report that their students were meeting the standards. Teachers in schools with a high percentage of minority students were less likely to say that all or most of their students are meeting the standards.

Do Teachers Think That the Curriculum Has Become More Demanding of Students?

The vast majority of teachers feel that the curriculum is becoming more demanding of students. In the 2000 study cited above, 79 percent of teachers reported that the curriculum is more demanding of students than three years ago: 39 percent reporting a lot more and 40 percent reporting somewhat more. Only 17 percent reported that there has been no change, and 4 percent reported that the curriculum has become less demanding. Elementary school teachers were more likely to say the current curriculum is more demanding, and middle and high school teachers were more likely to say that there has been no change in the level of the curriculum. Teachers in states with exit exams, those teaching a high percentage of minority students, and those teaching where standards have been put in place more recently (since 1995) were more likely than other teachers to report that the curriculum has become more demanding over the three-year period.

Among teachers who reported that the curriculum is more demanding, nearly two-thirds said that this change is the result of new statewide academic standards. An additional 20 percent responded that a combination of other factors and the standards have resulted in the more demanding curriculum, and 16 percent said that it was due solely to other factors. Math teachers were more likely than English, science, or social studies teachers to report new standards as having made the curriculum more demanding, as were teachers in schools where more than 10 percent of the students received free lunch.

How Do Teachers View Testing?

Have the new statewide standards led to teaching that focuses too much on state tests? Two-thirds of teachers said that this is the case: a third stated that statewide standards had led to far too much time focused on testing, and another third indicated that this was somewhat the case. Most of the remaining teachers said that the focus is just right. Similarly, two-thirds of the teachers surveyed agreed more with the statement, “State testing is forcing you to concentrate too much on information that will be on the test to the detriment of other important areas” as opposed to “State testing is helping you as a teacher to focus on teaching what children really need to know.”

How Much Do Teachers Integrate Standards and Testing Into Their Teaching?

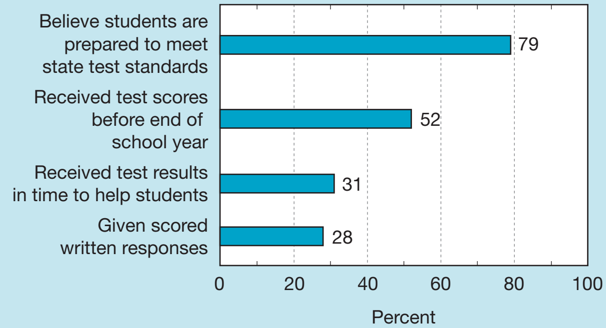
The 2000 *Education Week* survey of public school teachers cited above also indicates that teachers feel prepared to implement state standards in their classrooms, more so than in the previous year (Belden, Russonello, and Stewart Research and Communications 2000). Almost all of the public school teachers (94 percent) reported that they have a copy of the statewide academic standards, and 84 percent said that they have modified their curriculum to reflect the standards (36 percent a “great deal” and 48 percent “somewhat”). A similar proportion said that they have adopted or developed modules, units, or lesson plans linked to the state standards.

A significant amount of “teaching to the test” appears to occur, but using these tests as diagnostic tools is also quite widespread. Nearly 8 out of 10 teachers reported instructing their classes in the previous year in test-taking skills, such as pacing themselves and filling in bubbles clearly (45 percent “a great deal” and 34 percent “somewhat”); 7 out of 10 teachers reported using individual results to help diagnose what students need (36 percent “a great deal” and 34 percent “somewhat”); and 6 out of 10 teachers reported using results to diagnose what they need to be teaching in their classes (32 percent “a great deal” and 42 percent “somewhat”). Nearly two-thirds of teachers said that they had amended what they taught in the previous year to fit what is on the state tests (22 percent “a great deal” and 43 percent “somewhat”). (See sidebar, “High School Teachers Have a Generally Favorable Opinion of State Graduation Tests.”) (See figure 1-12.)

While the data in this section have shown that the vast majority of states have adopted content standards in mathematics and science and that state-wide testing in these subjects is increasing, a number of studies raise concerns over the degree to which state tests align with state standards. For example a recent study from the American Federation of Teachers found that “no state or the District of Columbia has a fully developed standards-based system that links quality standards to tests, curriculum and accountability measures” (AFT 2001). This study found that:

- ♦ Almost a third of the states’ tests are based on weak standards;
- ♦ Forty-four percent of those tests are not aligned to the standards;
- ♦ Fewer than one-third of the tests are supported by adequate curriculum; and

Figure 1-12.
Opinion on preparation for and utility of state test by public high school teachers whose state has graduation test: 2000



NOTE: Data are based on responses to the following questions:
Q51. Are students well prepared enough to meet the standards on the tests, or are they ill prepared?
Q52. Last year, did you receive your students’ scores on the state exams before the end of the year?
Q53. Last year, did you receive your individual students’ test results early enough in the year or too late to be helpful in working with those individuals?
Q55. Are you given copies of your students’ scored written responses on the state exams?

SOURCE: Belden, Russonello, and Stewart Research and Communications, *Making the Grade: Teachers’ Attitudes Toward Academic Standards and State Testing: Findings of National Survey of Public School Teachers for Education Week* (Washington, DC: 2000).

Science & Engineering Indicators – 2002

- ♦ One-third of the tests used in decisions regarding promotion or graduation are not aligned to the standards.

While other studies come up with different numbers, the problem of alignment between standards, testing, instruction and accountability remains a common theme (e.g., Achieve, Inc. 2001; CCSSO 2001; Finn and M.J. Petrilli 2000). (See sidebar, “A Survey of Curriculum Use in Classrooms.”) Data presented in this section show that both teachers and the general public support standards and testing, although the latter more strongly than the former. The next section examines how the organization of the math and science curriculum in the United States differs from other countries and reviews current measures of the quality of mathematics instruction.

Curriculum and Instruction

Debate continues over the effectiveness of two distinct instructional approaches: (1) emphasis on drill and practice activities in which students work toward skill mastery and (2) emphasis on reasoning, conceptual understanding, and skill application. This debate is driven by differences in opinion regarding the nature of the curriculum as well as different theories about how people learn. Although whole-group instruction and worksheets are still commonly used , the majority of American teachers report using small-group instruction as well as using manipulatives or models to dem-

High School Teachers Have a Generally Favorable Opinion of State Graduation Tests

In the 2000 survey of public school teachers conducted for *Education Week,* a series of questions on testing was asked of public high school teachers who reported that they have a state graduation test. Generally, these high school teachers have favorable opinions of the graduation test.

- A majority (54 percent) believed that the graduation test in their state is appropriate. Only 1 in 10 (13 percent) believed it is too difficult, and 15 percent believed it is too easy. Twenty percent (2 in 10) were unable to offer an opinion of the test.
- A total of 8 in 10 (79 percent) reported that their students are well prepared to meet the standards on the tests. Only 1 in 10 (13 percent) believed that their students are ill prepared.

These high school teachers differed widely, however, on whether the tests are helpful as a diagnostic tool.

- Fifty-eight percent of the teachers reported that test results are helpful for improving their own teaching. Only 1 in 10 (11 percent) found the test results very helpful, and 47 percent said they are somewhat helpful. One-quarter of high school teachers said the results are not at all helpful.

One reason these high school teachers may not find the tests more useful is that the teachers are not receiving the results, or if they are, they are not receiving them in time to implement changes.

- Only half (52 percent) of these high school teachers received their students' scores on the state exams before the end of the year.
- Only 3 in 10 (31 percent) said they received the test results early enough to help individual students.
- Only 3 in 10 (31 percent) were given copies of their students' scored written responses on the state tests.

NOTE: Based on a sample of 173 high school teachers who said their state has a graduation test.

SOURCE: Belden, Russonello, and Stewart Research and Communications 2000.

onstrate a concept (Henke, Chen, and Goldman 1999).[9] Data from the TIMSS video study indicate, however, that teacher implementation of the kinds of instructional techniques for mathematics advocated in the NCTM standards are often superficial. National data that link these approaches to differences in learning outcomes are sparse. This section reviews the most recent data available on curriculum and instruction.

Data from the TIMSS video study show considerable cross-national variation in curricular approaches used in mathematics instruction. For example, American and German middle school mathematics lessons focus primarily on the acquisition and application of skills, but Japanese lessons stress problem solving and thinking. Furthermore, the quality of U.S. mathematics lesson plans was judged to be substantially below that in Germany and Japan in an evaluation by U.S. college mathematics teachers. International studies have also shown that U.S. math and science textbooks cover comparatively more topics with less depth of coverage and development. Recent studies by the American Association for the Advancement of Science (AAAS) have found the most widely used middle school mathematics textbooks and high school science (e.g., biology) textbooks to be less than satisfactory (AAAS 1999a,b and 2000a,b).

Both the new mathematics and the new science standards envision instruction that challenges students, but neither provides an exact blueprint for action. Measuring the extent to which this vision is becoming a reality is difficult because available methods cannot measure quality directly. Instead, educational researchers have relied most often on indicators of the amount of time students spend studying a subject (classwork and homework), the content of lessons, and the types of instructional resources used (e.g., textbooks). This section reviews instructional and curricular topics where recent data collection and research have been strongest: international comparisons of time spent studying mathematics and science, cross-national comparisons of curricular structure, and evaluations of the quality of mathematics and science textbooks. Although these lines of research have yielded valuable information for education policymakers, much remains to be learned about how to make mathematics and science instruction more effective.

Instructional Time

The question of whether U.S. students spend enough time in school or receiving instruction has persisted for many years, and research results on this issue are mixed. Research by Stigler and Stevenson (1991) showed that U.S. students spend fewer hours in school than Japanese students and that U.S. schools allocate less time to core instruction than do other industrialized nations. For example, core academic time in U.S. schools was estimated at 1,460 hours during the four years of high school compared with 3,170 hours in Japan. NECTL reported in 1994 that at the time of the Commission's study, only 10 states specified the number of hours to be spent in academic subjects at various grades. Only eight others provided recommendations regarding academic time. Based on these and other findings, the Commission concluded: "[T]ime is the missing element in the debate about the need for higher academic standards.…We have been asking the impossible of our students—that they learn as much as their foreign peers while spending only half as much time in core academic studies" (NECTL 1994).

[9]Manipulatives are materials designed to provide concrete, hands-on experiences that can help students make the link between math concepts and the real world.

A Survey of Curriculum Use in Classrooms

States' movement toward standards-based reform in mathematics and science has produced strong interest in reliable data for evaluating the effects of reforms. A recent study by the Wisconsin Center for Education Research (WCER) and the Council of Chief State School Officers (CCSSO) applied research-based models and instruments for studying the curriculum to the broader purpose of reporting indicators of curriculum and instruction that could be used by policymakers and educators. States were asked to voluntarily participate in the study if they were interested in gaining information on effects of their reform efforts and gaining knowledge about the development and use of a survey approach to analyzing curriculum. In 1999, schools and teachers in 11 states participated in a study of the enacted curriculum in mathematics and science classrooms. Half the schools selected had high involvement in their state's initiative for improving math or science education ("Initiative" schools), and the other half were schools with less involvement but were similar to the first group based on student demographics ("Comparison" schools). More than 600 teachers across the states completed self-report surveys that covered the subject content they taught and the instructional practices they used in their classes. The enacted curriculum data were designed to give states, districts, and schools an objective method of analyzing current classroom practices in relation to content standards and the goals of systemic initiatives. This National Science Foundation-funded study was a collaborative effort involving state education leaders in science and mathematics, researchers from WCER, and project managers from CCSSO. Educators and researchers worked together to develop survey instruments that would gather reliable data from teachers and students and to develop formats for reporting survey results that would communicate key findings to educators. The goals of the study were to:

- ♦ measure differences in instructional practices and curriculum content among teachers and schools,
- ♦ determine whether state policy initiatives and state standards lead to differences in math and science teaching, and
- ♦ demonstrate the use of "surveys of enacted curriculum" to analyze classroom practices and to produce useful analyses and reports for educators.

The findings from the 1999 study listed below typify the types of issues and questions that can be explored with the survey data.

Active Learning in Science

Question: To what extent are students involved in active, hands-on learning approaches in science class?

- ♦ Sample survey data suggest one-fourth of science class time is spent on hands-on science or laboratory activities, but there is wide variation among schools.
- ♦ Survey data allow comparison of active science methods in schools that are involved in state initiatives and of science teaching in typical schools.

Problem Solving in Mathematics

Question: To what extent are students in math class learning problem-solving and reasoning skills and learning how to apply knowledge to novel problems?

- ♦ A majority of teachers report teaching problem solving in math, but teachers use a wide variety of instructional practices, such as small groups, writing, data analysis, and applying concepts to real-world problems.
- ♦ Differences are found in the types and depth of instruction of problem-solving activities between schools involved in state initiatives and comparison schools.

Mathematics and Science Content in Classrooms

Question: How does math and science content taught in classes compare to the goals outlined in state and national standards?

- ♦ In middle-grade math and science, most recommended standards are covered, but the level of expectation and depth of coverage vary widely among schools and classes.
- ♦ Data reveal differences in the extent of teaching science content across the standards and the extent of articulation between grades.
- ♦ Schools differ in their emphasis on algebra, geometry, and data and statistics in the elementary and middle grades.

Multiple Assessment Strategies in Math and Science

Question: What methods of student assessment are used in class, and are the strategies consistent with goals of learning in content standards?

- ♦ A majority of teachers use multiple assessment methods in math and science classes but infrequently use extended student responses that require student explanation and justification of answers.
- ♦ In science, the survey data allow analysis of differences in the use of performance tasks (hands-on activities) for assessment in class.

Use of Education Technology and Equipment

Question: How is education technology, e.g., calculators and computers, used in math and science instruction? Do teachers have science equipment available in their classes, and how often is it used?

- ♦ A majority of elementary- and middle-grade teachers use calculators in teaching math; graphing calculators are available in the typical grade 8 classroom but are rarely used.
- ♦ The average elementary school classroom has basic science equipment, but rate of use varies widely among teachers.

Influences on Curriculum and Practices

Question: What effect do state and national standards for science and math learning have on the curriculum taught in classrooms?

- ♦ State frameworks and standards and national standards are reported by most teachers to have strong positive influences on their curriculum.
- ♦ Survey data allow comparisons of degree of influence on curriculum of state and national standards, textbooks, state and district tests, and teacher preparation and knowledge.

Alignment of Content Taught With State Assessments

Question: Do state assessments reflect what is being taught in classes?

- ♦ Analysis of teacher reports and state assessment items shows that tests cover a narrower range of expectations for students than are reported for instruction: tests focus more on memorization, facts, and performing procedures and less on solving novel problems and applying skills and concepts.
- ♦ The data on alignment between teacher reports on instruction and content and state assessments allow teachers and assessment staff to examine the areas of weakness and strength of tests and classroom practices.

Teacher Preparation

Question: How well prepared are our teachers to teach science and mathematics?

- ♦ The survey data show how well prepared teachers are for using innovative teaching strategies and handling students with varied needs and capacities.
- ♦ Middle-grade teachers in math and science receive more professional development than elementary school teachers both in methods of teaching and subject content. Teachers report very positive reactions to professional development related to standards, curriculum, and assessment.

SOURCE: CCSSO 2000b.

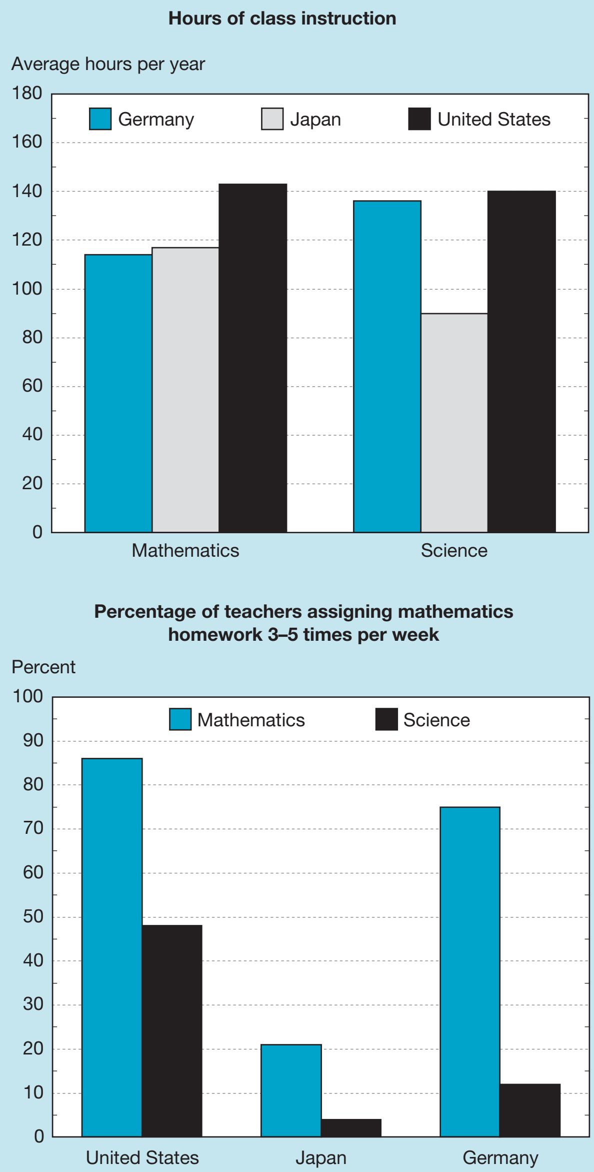
This may not be the case for mathematics and science, as 1995 and 1999 data for 8th graders from TIMSS and TIMSS-R suggest. Eighth-grade students in the United States receive at least as much classroom time in mathematics and science instruction as students in other nations: close to 140 hours per year in mathematics and 140 hours per year in science in 1994-95. (See figure 1-13.) Students in Germany, Japan, and the United States spent about the same amount of time on a typical homework assignment, but U.S. students were assigned homework more often, thus increasing total time spent studying in the two subjects (Beaton et al. 1996b; NCES 1997a,c and 1996c).

Certain caveats are necessary in interpreting results on instructional time. First, in other nations, particularly Japan, students participate in extracurricular mathematics and science activities in afterschool clubs or in formal tutoring activities. Second, disruptions for announcements, special events, and discipline problems in U.S. classrooms considerably reduce the amount of classroom time actually spent on instructional activities (Stigler et al. 1999).

Curriculum and Textbook Content

Analyses conducted in conjunction with TIMSS (Schmidt, McKnight, and Raizen 1997) documented that curriculum guides in the United States include more topics than is the international norm. Most other countries focus on a limited number of topics, and each topic is generally completed before a new one is introduced. In contrast, U.S. curriculums

Figure 1-13.
Selected characteristics of grade 8 mathematics and science instruction, Germany, Japan and United States: 1994–95



NOTE: Data are from the Third International Mathematics and Science Study.

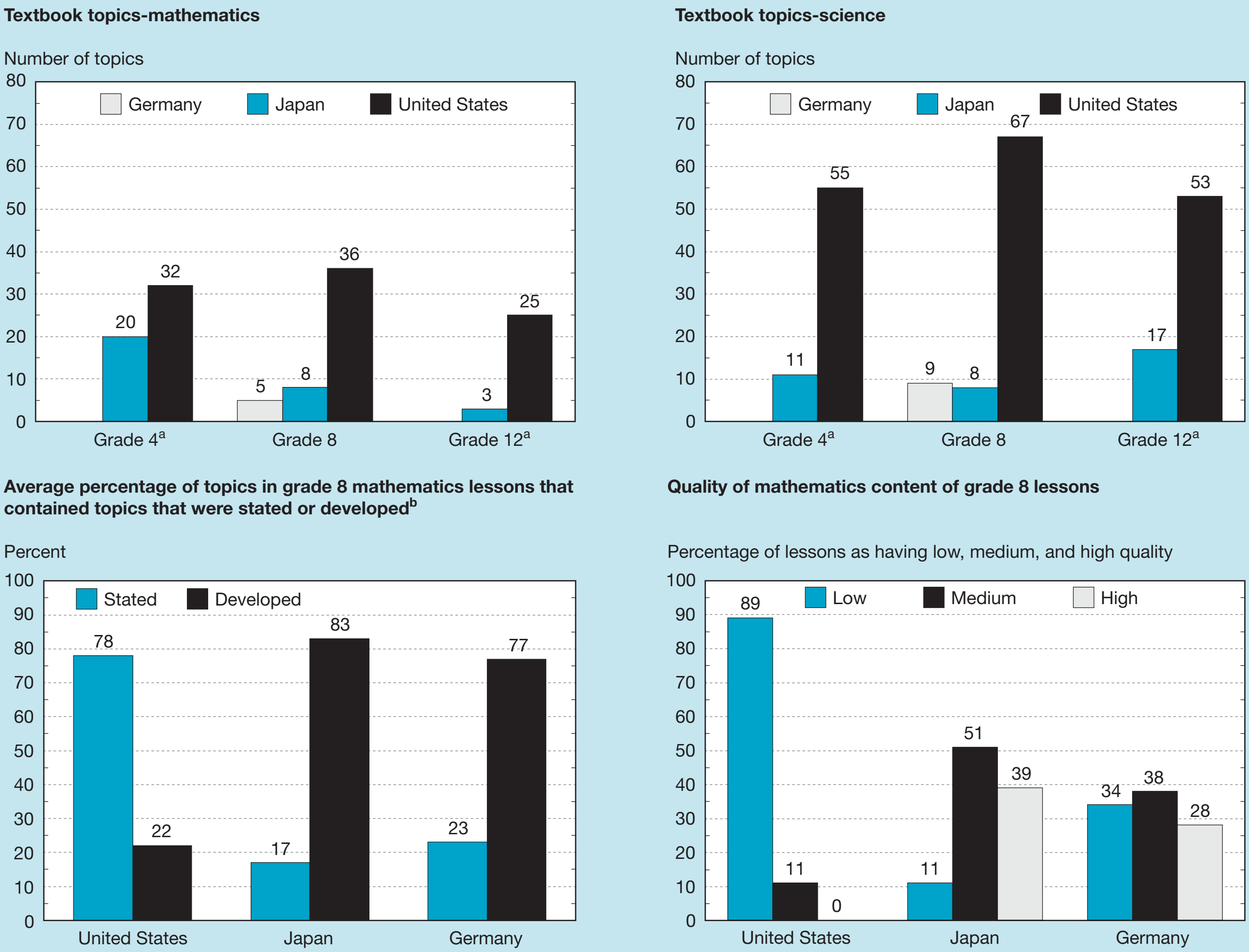
SOURCE: National Center for Education Statistics, *Pursuing Excellence: A Study of U.S. Eighth Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context*, NCES 97-198 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 1996c).

Science & Engineering Indicators – 2002

follow a "spiral" approach: topics are introduced in an elemental form in the early grades, then elaborated and extended in subsequent grades. One result of this is that U.S. curriculums are quite repetitive, because the same topic appears and reappears at several different grades. (See figure 1-14.) Another result is that topics are not presented in any great depth, giving the U.S. curriculum the appearance of being unfocused and shallow.

The Schmidt, McKnight, and Raizen (1997) study also suggests that U.S. curriculums, especially math, make fewer intellectual demands on students, delaying until later grades topics that are covered much earlier in other countries. U.S. mathematics curriculums also were judged to be less advanced, less challenging, and out of step with curriculums in other countries. The middle school curriculum in most TIMSS countries, for example, covers topics in algebra, geometry, physics, and chemistry. Meanwhile, the grade 8 curriculum in U.S. schools is closer to what is taught in grade 7 in other countries and includes a fair amount of arithmetic. Science curriculums, however, are closer to international norms in content and in the sequence of topics. Textbooks reflect the same inadequacies documented by curriculum analyses: insufficient

Figure 1-14.
Selected characteristics of grade 4, 8, and 12 mathematics and science instruction, Germany, Japan, and United States: 1994–95



[a]Data for Germany not available.

[b]A concept was coded as "stated" if it was simply provided by the teacher or students but was not explained or derived. A concept was coded as "developed" when it was derived and/or explained by the teacher or the teacher and students collaboratively in order to increase students' understanding of the concept.

NOTE: Data are from the Third International Mathematics and Science Study. Eighth-grade algebra texts are not included.

SOURCE: J.W. Stigler, P. Gonzales, T. Kanaka, S. Knoll, and A. Serrano, *The TIMSS Videotape Classroom Study: Methods and Findings From an Exploratory Research Project on Eighth-Grade Mathematics Instruction in Germany, Japan, and the United States,* NCES 1999-074 (Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement: 1999; W.H. Schmidt, C.C. McKnight, and S.A. Raizen, *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education.* Boston, MA: Kluwer Academic Publishers: 1997).

Science & Engineering Indicators – 2002

coverage of many topics and insufficient development of topics. (See figure 1-14.) Compared to textbooks used in other countries, science and mathematics textbooks in the United States convey less challenging expectations, are repetitive, and provide little new information in most grades, a finding reported in earlier research by Flanders (1987) and by Eyelon and Linn (1988). Publishers have made some attempts to reflect the topics and demands conveyed by the educational standards; however, the TIMSS curriculum analyses suggest that when new "standards-referenced" topics are added, much of the old material is retained (Schmidt, McKnight, and Raizen 1997).

Recent studies by AAAS (1999a,b) have reinforced the findings of TIMSS and other studies about the inadequacies of mathematics and science textbooks. AAAS conducted a conceptual analysis of content based on 24 instructional criteria and applied them to the evaluation of 9 middle-school science texts and 13 mathematics texts. The samples included the most widely used texts in both subjects. Each text was evaluated by two independent teams of middle school teachers, curriculum specialists, and science and mathematics education professors. AAAS developed and tested the evaluation procedure over a three-year period in collaboration with more than 100 scientists, mathematicians, educators, and curriculum developers. On a 0- to 3-point scale (where 3 represents "satisfactory"), all nine science textbooks scored below 1.5. Six mathematics texts scored below 1.5, and only three scored above 2.5 points (AAAS 1999a,b).

Similar evaluations of high school biology and algebra texts were only slightly more supportive of their content. In a 2000 evaluation of 10 widely used and newly developed biology textbooks, none received high ratings (AAAS 2000b). Two independent teams of biology teachers, science curriculum specialists, and professors of science education evaluated each biology text, along with its teacher guide. The evaluation examined how well the texts are likely to help students learn the important ideas and skills in the widely accepted Benchmarks for Science Literacy (developed earlier by AAAS Project 2061) and in the National Science Education Standards (NRC 1996). Directors of this study reported, for example, that the textbooks ignore or obscure the most important biological concepts by focusing instead on technical terms and trivial details (which are easy to test) and that activities and questions included are inadequate to help students understand many of the more difficult concepts.

Among the 12 high school algebra textbooks evaluated by AAAS Project 2061, 7 were considered adequate; however, not one was rated highly (AAAS 2000a). Five textbooks, including three that are widely used in American classrooms, were rated so inadequate that they lack potential for student learning. Highlights of the evaluation included the following:

- ♦ All of the textbooks present algebra using a variety of contexts and give students appropriate firsthand experiences with the concepts and skills.
- ♦ Most of the textbooks do an acceptable job of developing student ideas about algebra by representing ideas, demonstrating content, and providing appropriate practice.
- ♦ No textbook does a satisfactory job of providing assessments to help teachers make instructional decisions based specifically on what their students have or have not learned.
- ♦ No textbook does a satisfactory job of building on students' existing ideas about algebra or helping them overcome their misconceptions or missing prerequisite knowledge.

Instructional Practice

Most information about instructional practice has come from surveys that asked teachers about specific aspects of their teaching. In a recent survey, 82 percent of full-time U.S. mathematics teachers and 74 percent of full-time science teachers gave themselves good grades on using practices consistent with educational standards in their fields (NCES 1999d). However, classroom observational studies, which have provided more depth and dimension to depictions of practice, often paint quite a different picture. These studies demonstrate that it is relatively easy for teachers to adopt the surface characteristics of standards-based teaching but much harder to implement the core features in everyday classroom practice (Spillane and Zeuli 1999; Stigler et al. 1999; and NCES 2000d).

The TIMSS video study of 8th-grade mathematics instruction is a case in point. Lessons in U.S., German, and Japanese classrooms were fully documented, including descriptions of the teachers' actions, students' actions, amount of time spent on each activity, content presented, and intellectual level of the tasks that students were given in the lesson (Stigler et al. 1999). These findings identified four key points:

- ♦ The content of U.S. mathematics classes requires less high-level thought than classes in Germany and Japan.
- ♦ The typical goal of U.S. mathematics teachers is to teach students how to do something, but the typical goal of Japanese teachers is to help them understand mathematical concepts.
- ♦ Japanese classes share many features called for by U.S. mathematics reforms, but U.S. classes are less likely to exhibit these features.
- ♦ Although most U.S. mathematics teachers report familiarity with reform recommendations, relatively few apply the key points in their classrooms.

Ratings by mathematicians of the quality of instruction in 8th-grade German, Japanese, and U.S. mathematics classrooms in 1994–95 suggest a lower level of quality in U.S. instruction. Approximately 30 percent of lessons in Japanese classrooms were rated as "high quality" and 13 percent were rated as "low quality." In German classrooms, 23 percent of lessons received high ratings and 40 percent received low ratings. In comparison, approximately 87 percent of U.S. lessons were considered "low quality" and none were considered "high quality." (See figure 1-14.) However, because of the small scale of the study, these results are suggestive rather than definitive. The studies are now being replicated on a larger scale in both mathematics and science.

Teacher Quality and Changes in Initial Teacher Training

Research suggests that school quality is tightly linked to teacher quality (NCES 2000d). According to Hanushek (1992), "The estimated difference in annual achievement growth between having a good and having a bad teacher can be more than one grade-level equivalent in test performance." Rivkin, Hanushek, and Kain (1998) recently concluded in one study that teacher quality is the most important determinant of school quality. Current research, however, has yet to definitively determine the specific, observable factors that distinguish a good teacher from a bad one. Research does suggest that the following factors are associated with teacher quality: having academic skills, teaching in the field in which the teacher received training, having more than a few years of experience (to be most effective), and participating in high-quality induction and professional development programs (NCES 2000d). Data relating to these issues were collected by the NCES during academic year 1999/2000 through the Schools and Staffing Survey (SASS). Data from sources other than the SASS have been included, to the extent possible.

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Measuring Academic Skills of Teachers

Research shows that students tend to learn more from teachers with strong academic skills than they do from teachers with weak academic skills (Ballou 1996; Ferguson and Ladd 1996; Ehrenberg and Brewer 1995, 1994; Ferguson 1991; Mosteller and Moynihan 1972). Some researchers argue that teacher quality has less to do with how teachers perform on standardized tests than with how they perform in the classroom (Darling-Hammond 1998). Although traits not measured on standardized tests (such as interpersonal skills, public speaking skills, and enthusiasm for working with children) influence whether someone will be an effective teacher, these traits tend to be hard to quantify, and most studies examining the link between teacher skills and student learning limit their definitions of teacher skills to academic skills (NCES 2000d).

Several studies show that over the past three decades, teachers with low academic skills have been entering the profession in much higher numbers than teachers with high academic skills (Henke, Chen, and Geis 2000; Gitomer, Latham, and Ziomek 1999; Ballou 1996; Henke, Geis, and Giambattista 1996; Murnane et al. 1991; Vance and Schlechty 1982). However, a recent study by the Educational Testing Service (ETS) suggests that the pattern for potential mathematics and science teachers may be different. ETS found that the teaching profession tends to attract teachers with below-average skills, based on the Scholastic Aptitude Test (SAT) scores of prospective teachers taking the Praxis II between 1994 and 1997 (Gitomer, Latham, and Ziomek 1999).[10] Based on a comparison of SAT scores for teacher candidates passing the Praxis II exam with the average score for all college graduates, ETS concluded that elementary education candidates, the largest single group of prospective teachers, have much lower math and verbal scores than other college graduates. The pattern in other content areas for teacher candidates was less consistent, however. The average math SAT score for those passing the Praxis II exam and seeking licensure in physical education, special education, art and music, social studies, English, or foreign language was lower than the average math score for all college graduates. Those seeking to teach science and math, however, had higher average math scores than other college graduates. The average verbal SAT scores of those seeking to teach some subjects were more encouraging. The scores of mathematics, social studies, foreign language, science, and English candidates who passed the Praxis II exam were as high as or higher than the average verbal SAT score for all college graduates. Physical education, special education, and art and music teachers scored below the average.

A major disadvantage of the ETS study, however, is that it examines only candidates, not those who actually take teaching jobs. Ballou (1996) demonstrated that there are large drop-offs in the pipeline. For example, although 20 percent of students from average colleges became certified to teach, 17 percent applied for teaching jobs and 8 percent actually became employed as teachers. Given such large drop-offs, one should not assume that individuals taking the Praxis II examination have the same characteristics as those who actually become teachers (NCES 2000d).

Several recent studies using data from the 1993 NCES Baccalaureate and Beyond Longitudinal Study provide more comprehensive pictures of the teacher pipeline, that is, from preparation at the baccalaureate level to employment (Henke, Chen, and Geis 2000; Henke, Geis, and Giambattista 1996). These studies found that the college entrance examination scores of 1992/93 college graduates in the teaching pipeline (defined by NCES as students who had prepared to teach, who were teaching, or who were considering teaching) were lower than those students who were not in the pipeline. "At each step toward a long-term career in teaching, those who were more inclined to teach scored less well than those less inclined to teach" (Henke, Geis, and Giambattista 1996). For example, by 1997, the 1992/93 college graduates in this study with the highest college entrance examination scores were consistently less likely than their peers with lower scores to prepare to teach, and when they did teach, they were less likely to teach students from disadvantaged backgrounds:

[10]The Praxis II assessments are designed to measure teacher candidates' knowledge of the subjects they will teach and how much they know about teaching that subject.

- Graduates whose college entrance examination scores were in the top quartile were half as likely as those in the bottom quartile to prepare to teach (9 versus 18 percent).
- Teachers in the top quartile of college entrance examination scores were more than twice as likely as teachers in the bottom quartile to teach in private schools (26 versus 10 percent).
- Teachers in the top quartile of scores were about one-third as likely as teachers in the bottom quartile to teach in high-poverty schools (10 versus 31 percent).
- Graduates in the top quartile of scores who did teach were twice as likely as those in the bottom quartile to leave the profession within four years (32 versus 16 percent) (Henke, Chen, and Geis 2000).

Match Between Teacher Background and Courses Taught

Research shows that assigning teachers to teach courses that they are not trained to teach has a negative effect on student achievement (Darling-Hammond 2000; Goldhaber and Brewer 1997; Monk and King 1994). In the early 1990s, however, it was quite common for students to be taught mathematics and science by teachers without a major or minor in those subjects, especially in schools with large concentrations of poor and minority students or those in rural areas (Ingersoll 1999). This section examines the "mismatch" between those teaching mathematics and science and their educational backgrounds in those fields using data from a recently released national survey of teachers, the NCES SASS. Because it is common for an individual teacher to teach courses in multiple fields simultaneously, examining the match between a teacher's main assignment field and his or her educational background can overestimate or, as is more likely, underestimate the amount of out-of-field teaching that is occurring. For this reason, the indicators presented below are calculated at the student level, that is, the percentage of students taught mathematics or science by a teacher without a major or minor in the related field. Unlike previously reported measures, these indicators attempt to measure the degree to which someone is teaching out of field, including whether he or she (1) has a major in the field at either the undergraduate or graduate level, (2) has a minor in the field, (3) has a major or minor in a related field of science, (4) has an education degree with a specialization in the field taught, or (5) has no previous education in the field as laid out in the four previous categories (referred to as "severely" out of field).

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Teacher Experience

Research suggests that students learn more from experienced teachers (those with at least five years of experience) than they do from less experienced teachers (NCES 2000d; Rivkin, Hanushek, and Kain 1998; Murnane and Phillips 1981). These studies point primarily to the difference between teachers with fewer than five years of experience (new teachers) and teachers with five or more years of experience. The benefits of experience, however, appear to level off after 5 years, and studies suggest that there are no noticeable differences, for example, in the effectiveness of a teacher with 5 years of experience versus a teacher with 10 years of experience (Darling-Hammond 2000). This section examines the proportion of students in middle and high schools who are taught by new teachers, defined here as teachers in their first three years of teaching.

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Induction of Recently Hired Teachers

Teacher recruitment and retention will become increasingly important as the baby boom generation reaches retirement age and its echo in terms of increased student enrollment makes its way through schools. In the 1980s and 1990s, large numbers of teachers left the profession after teaching just a few years. For example, between the 1993/94 and 1994/95 academic years, the most recent years for which national attrition data exist, 17 percent of teachers with three or fewer years of experience left the profession (NCES 2000d). Nine percent left after teaching for less than one year. A disproportionately high share left high-poverty schools. In efforts to retain good teachers, schools are increasingly using mentorships with master teachers and formal "induction" programs. This section examines the characteristics of the initial training of mathematics and science teachers who entered the profession between 1994/95 and 1999/2000 and examines the degree to which these new teachers reported receiving different types of support in their first year of teaching.

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Teacher Professional Development

Many experts assert that high-quality professional development should enhance student learning, but data for undertaking the requisite analysis are sparse. Almost all teachers participate in some form of professional development over the course of a year, most for the equivalent of a day or less. Teachers who spend more time in professional development activities are more likely to self-report improvements in classroom teaching as the result of these activities than are those who spend less time. Although several reports have asserted that teachers will perform better if they are given opportunities to sharpen their skills and keep abreast of advances in their fields (Henke, Chen, and Geis 2000; National Commission on Teaching and America's Future 1996), there has been no comprehensive assessment of the availability of such learning opportunities and the effects of those opportunities on teachers and students (Mullens et al. 1996; Smylie 1996). This section reviews participation in three types of professional development activities by mathematics and science teachers in 1999/2000:

- activities focused on indepth study of their content areas,
- activities focused on methods of teaching, and
- activities focused on the use of computers for teaching.

The amount of time teachers spent in these activities and whether they found them useful are also reviewed.

> Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

Observation of Other Teachers Teaching

Some research suggests that the experience of teachers observing other teachers can contribute to the sharing of good practices. TIMSS-R asked the mathematics and science teachers of U.S. 8th-grade students during the 1998/99 academic year about the number of class periods they observed other teachers during the past year and the number of periods other teachers observed them during the past year (NCES 2000f).[11] In general, the mathematics teachers of U.S. 8th-grade students rarely participated in observational activities. On average, U.S. 8th-grade students were taught by mathematics teachers who spent one class period during the 1998/99 academic year observing other teachers and who were observed by other teachers during two class periods. There were no differences in the average number of class periods that mathematics teachers observed other teachers or were observed by other teachers based on years of teaching experience.

The science teachers of U.S. 8th-grade students also rarely participated in observational activities. On average, U.S. 8th graders were taught by science teachers who observed other teachers for one class period during the 1998/99 academic year and who were observed by other teachers for one class period. However, the situation was different for U.S. 8th-grade students whose science teachers had the fewest years of experience (0–5 years): their teachers spent approximately three periods observing other teachers, a greater number of periods than science teachers with more years of experience (NCES 2000f).

[11]Questions regarding the professional development of teachers, including whether or not they had observed other teachers teaching in the previous year, were only asked of U.S. mathematics and science teachers in TIMSS-R.

Teacher Working Conditions

Salaries for math and science teachers remain well below those of bachelor's and master's degree scientists and engineers in industry. Given that teacher retirements are on the rise, increased salaries provide a means of retaining good teachers and attracting the number of quality teachers needed to replace retirees. The difference between the annual median salaries of all bachelor's degree recipients and teachers has declined over the past 20 years, mainly due to increases in the relative size of the older teaching workforce and in salaries of older teachers. This section reviews how average teacher salaries have changed over the past quarter century, how the earnings of math and science teachers vary in high- and low-poverty schools, and, finally, how the salaries and teaching time of U.S. teachers compare with those of their counterparts in other countries.

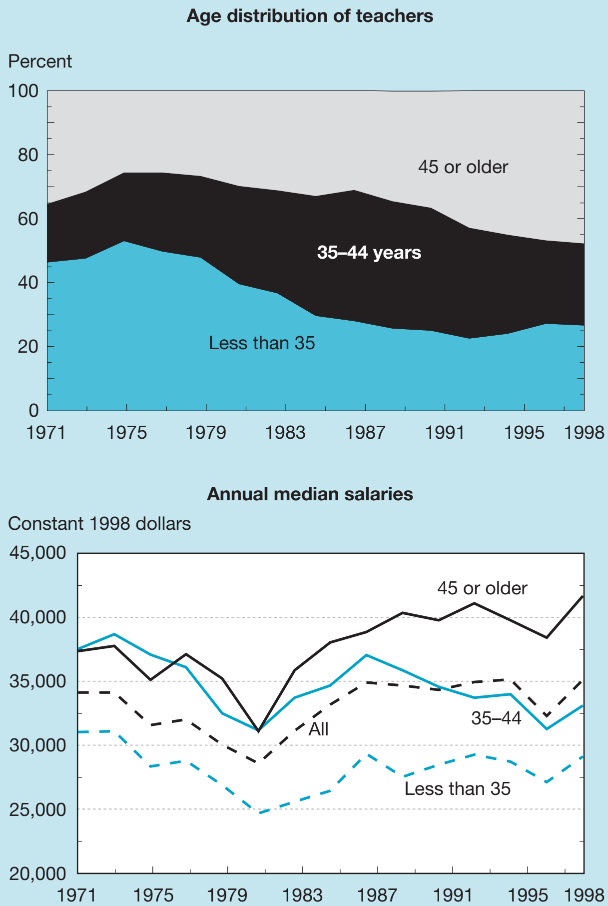
Salary and teaching time are only two components of teacher working conditions. The amount of professional development time supported by a school or district, student behavior, participation in school decisionmaking, class size, quality of facilities, and adequacy of resources are examples of conditions that could also influence a teacher's desire to teach or not teach at a particular school. Many of these conditions, however, are either difficult to measure or do not have a parallel in S&E occupations outside teaching.

Trends in Teacher Salaries

As a wave of younger teachers hired in the mid-1970s has aged, a demographic shift in the age of teachers has occurred (NCES 1999a). For example, in 1975, 53 percent of all full-time teachers were younger than age 35; in 1993, the percentage of younger teachers fell to about 23 percent. By 1998, the percentage of younger teachers had risen only slightly, reaching 27 percent. Meanwhile, the percentage of full-time teachers age 45 years or older increased from about 26 percent in 1975 to 48 percent in 1998. (See figure 1-15.) Average teacher salaries have been affected by these demographic shifts, particularly over the past 20 years.

The annual median salaries (in constant 1998 dollars) of full-time teachers decreased between 1971 and 1981 by about

Figure 1-15.
Age distribution and annual median salaries by age of full-time elementary and secondary school teachers: 1971–98



NOTE: Median salaries refer to previous calendar year, for example, salaries reported in 1971 refer to salaries earned in 1970. Consumer Price Index (CPI) used to calculate constant dollars. Includes full-time public and private school teachers who taught grades 1–12.

SOURCE: National Center for Education Statistics, *The Condition of Education 1999*, NCES 1999-022 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 1999a).

Science & Engineering Indicators – 2002

$500 to $700 annually in each age group. Between 1981 and 1989, the salaries of teachers rose. The annual median salary of full-time teachers grew slowly during the 1990s, reaching $35,099 in 1998 (NCES 1999a). For the oldest group of teachers, salaries rose by about $1,100 per year on average, while for the middle-aged and youngest groups, salaries increased by smaller amounts. Since 1989, the salaries of the oldest and youngest groups of teachers have remained about the same, while the salaries of the middle-aged group (between ages 35 and 44) have declined by about $400 per year on average. (See figure 1-15.)

The difference between the annual median salaries of bachelor's degree recipients and all full-time teachers declined from about $5,000 in 1981 to $2,300 in 1998. This decline in the salary gap has been due mainly to increases in the relative size of the older teaching workforce and in the salaries of teachers age 45 or older (NCES 1999a).

Variation in the Salaries of Math and Science Teachers

Many believe that competitive salaries and benefits are key to attracting and retaining high-quality teachers (Murnane et al. 1991). Research has shown that levels of compensation and criteria for awarding salary increases affect who goes into teaching, who stays, and how teachers move from district to district and from school to school (Odden and Kelley 1997). When asked whether various factors were important to them in determining the type of work they planned to do in the future, 1992/93 bachelor's degree recipients responded affirmatively to "income potential over career" and "intellectually challenging work" (45 percent in each case) more often than to any of the other factors mentioned (Henke et al. 1997). This section examines variability in the compensation levels of mathematics and science teachers in 1999/2000 across high- and low-poverty districts by school location.

Nationally representative data on teacher quality, professional development, and working conditions have been collected by the National Center for Education Statistics' (NCES) 1999–2000 Schools and Staffing Survey. They were not available in time for the preparation of this chapter. Following release of the dataset by NCES, analyses of these topics will be available at the following National Science Foundation website: <http://www.nsf.gov/sbe/srs/seind02/update.htm>.

International Comparisons of Teacher Salaries

Internationally, teacher pay scales in the United States tend to be lower than those in a number of other countries, including Germany, Japan, South Korea, and the Netherlands, and teaching hours tend to be longer. The gaps are particularly wide at the upper secondary (high school) level because a number of countries, unlike the United States, require higher educational qualifications and pay teachers significantly more at this level than at the primary (elementary) level. For example, salaries for upper secondary teachers with 15 years of experience and the minimum level of education and training required to be certified exceeded $40,000 in 1998 in Denmark, Germany, Japan, and the Netherlands and exceeded $60,000 in Switzerland (Organisation for Economic Co-operation and Development (OECD) 2000). The comparable salary for the United States was $35,000. This section reviews cross-country variation in teacher salary, adjusting first for differences in country wealth or ability to spend on education, and second for differences in the amount of time that teachers are required to spend in instructional activities to earn their salaries.

Association Between Teacher Salaries and Per Capita Gross Domestic Product

Teacher salaries relative to per capita gross domestic product (GDP) are an indication of the extent to which a country invests in teaching resources relative to the financial ability to fund educational expenditures. A high salary relative to per capita GDP suggests that a country is making more of an effort to invest its financial resources in teachers. Relative to per capita GDP, teacher salaries are relatively low in the Czech Republic, Hungary, and Norway and relatively high in South Korea, Spain, and Switzerland.

Wealthier countries do not necessarily spend a greater share of their wealth on educational resources, however. (See figure 1-16.) Although the Czech Republic and Hungary have both relatively low GDP per capita and low teacher salaries, other countries with GDP per capita below the OECD average, including South Korea and Spain, have comparatively high teacher salaries. Norway and the United States, two countries with relatively high GDP per capita, spend a below-average share of their wealth on teacher salaries, and Switzerland spends an above-average share of its relatively high per capita GDP on teacher salaries.

Salaries Adjusted for Statutory Teaching Time

Another measure of the investment in teaching is the statutory teacher salary relative to the number of hours per year that a full-time classroom teacher is required to teach students. This measure reflects the fact that teaching time is organized differently across countries, influenced by both the number of instructional hours planned for students each year and the proportion of the working day that a full-time teacher is expected to be engaged in direct instruction. Although this measure does not adjust salaries for the amount of time that teachers spend in all teaching-related activities, it can nonetheless provide a rough estimate of the cost of an hour of instruction across countries.

The average statutory salary per teaching hour after 15 years of experience is $35 in primary education, $43 in lower secondary education, and $52 in upper secondary (general) education across OECD countries (OECD 2000). For primary education, the Czech Republic, Hungary, and Mexico have relatively low salary costs per hour of instruction ($13, $15, and $16, respectively); by contrast, costs are relatively high in Denmark ($48), Germany ($49), South Korea ($62), and Switzerland ($48). Salary costs per primary teaching hour in the United States are in the middle of this range at $35. In South Korea, high costs per teaching hour at the primary level are balanced by a relatively high student/teacher ratio (31.2) and a low proportion of current expenditure on nonteaching staff, resulting in below-average expenditure per student (OECD 2000). In contrast, Denmark's high costs per teaching hour at the primary level combine with a relatively low student/teacher ratio (11.2) and an above-average expenditure on nonteaching staff to create one of the highest expenditure-per-student figures in the OECD. There is more variability in salary cost per hour of teaching in upper secondary schools, ranging (among OECD countries) from $16 or below in the Czech Republic and Hungary to $90 or above in Denmark and South Korea. Comparable costs for the United States were $38.

IT in Schools

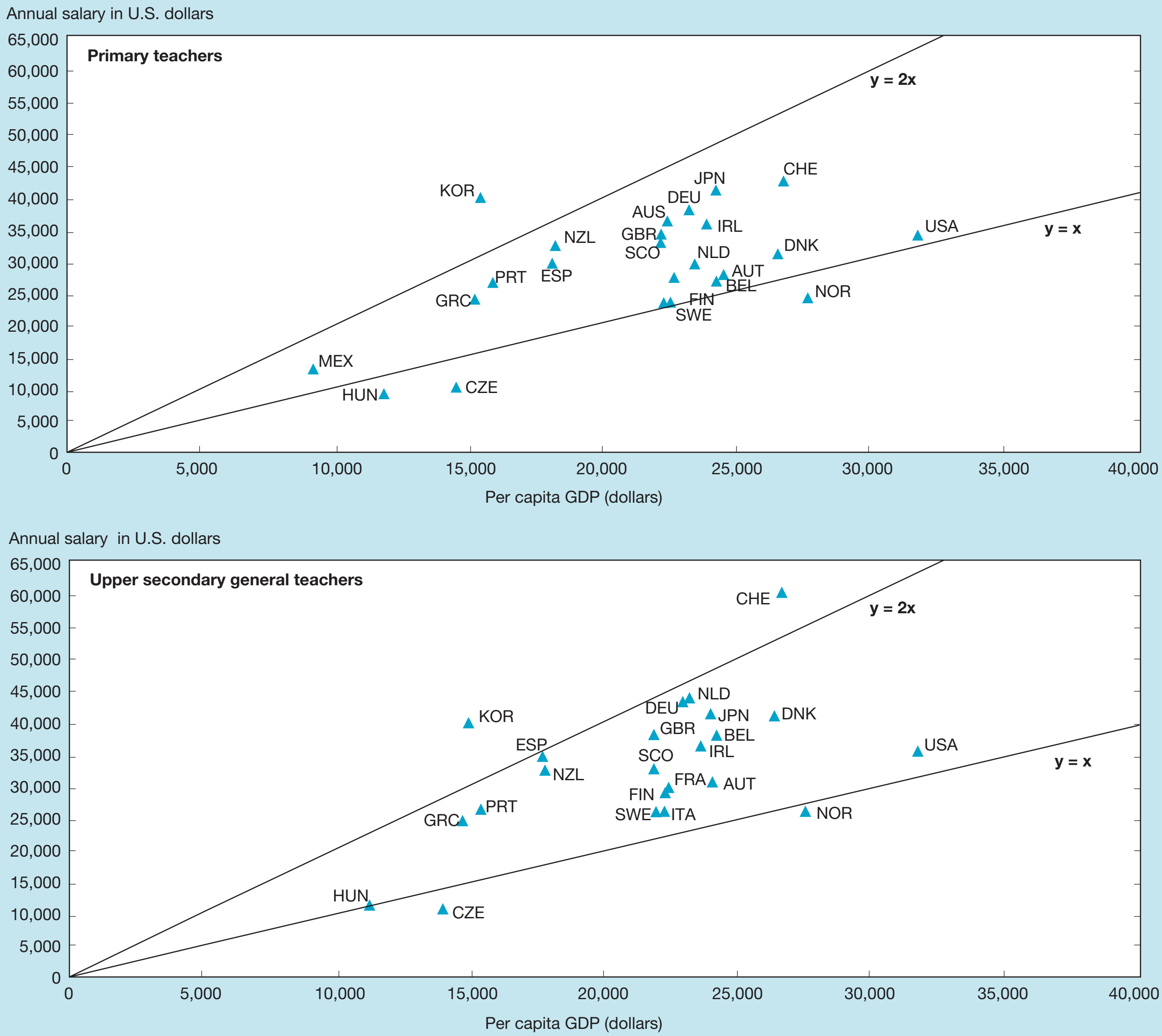
Although myriad approaches have been proposed for improving K–12 education in the United States, one common element of many such plans is more extensive and more effective utilization of computer, networking, and other information technologies (IT) to support a broad program of systemic and curricular reform (President's Committee of Advisors on Science and Technology 1997). IT has fundamentally transformed America's offices, factories, and retail establishments. Although the transformation in schools has been quite modest by comparison, technology and computers are rapidly appearing in schools and classrooms, and their integration into the curriculum is redefining the perception of a quality school (NCES 2000d).

Computers and Internet access are used in a variety of ways in schools, and each use may have an independent effect on student learning. Relatively little research on the effect of technology on learning looks at the uses and effects of Internet access; most research examines the instructional power of the computer to teach discrete skills (NCES 2000d). Numerous studies conducted in the elementary and secondary grades have concluded that student learning is enhanced by computers when the computer is used to teach discrete skills in the style referred to as "drill and practice." The benefits appeared to be strongest for students of lower SES, low achievers, and those with certain learning problems (President's Committee of Advisors on Science and Technology 1997).

Research on the application of computers for developing higher order thinking skills, problem-solving, group work, and hands-on learning activities, however, is less extensive and less conclusive (NCES 2000d). Two studies show positive effects (Wenglinsky 1998; Glennan and Melmed 1996), but a third study concludes that it is not known whether computers can be used for this type of teaching in a cost-effective manner with any "degree of certainty that would be desirable from a public policy viewpoint" (President's Committee of Advisors on Science and Technology 1997). Although it is possible that these studies are less conclusive because teachers are less adept at teaching using these new tools, it is clear that IT is becoming increasingly important in the classroom and that there is widespread interest in how these tools are being applied.

This section first examines student and teacher access to IT at school. Variability in access across high- and low-poverty schools is emphasized. Next, teacher use of IT in the classroom and at home, teacher preparation and training in IT, and barriers to IT use are examined. Because computers are not the only technology used in schools, the section concludes with a discussion of calculator usage in mathematics classes and how this varies cross nationally.

Figure 1-16.
Annual statutory teacher salaries after 15 years of experience relative to per capita GDP: 1998



Australia	AUS	Germany	DEU	Mexico	MEX	South Korea	KOR
Austria	AUT	Greece	GRC	Netherlands	NED	Spain	ESP
Belgium	BEL	Hungary	HUN	New Zealand	NZL	Sweden	SWE
Czech Republic	CZE	Ireland	IRL	Norway	NOR	Switzerland	CHE
Denmark	DNK	Italy	ITA	Portugal	PRT	United Kingdom	GBR
Finland	FIN	Japan	JPN			United States	USA
France	FRA						

GDP = Gross Domestic Product

NOTE: Countries above the y = 2x line had teacher salaries more than twice their per capita GDP while countries below the y = x line had teacher salaries below their per capita GDP.

SOURCE: Organisation for Economic Co-operation and Development. *Education at a Glance: OECD Indicators*, 2000 Edition (Paris: 2000).

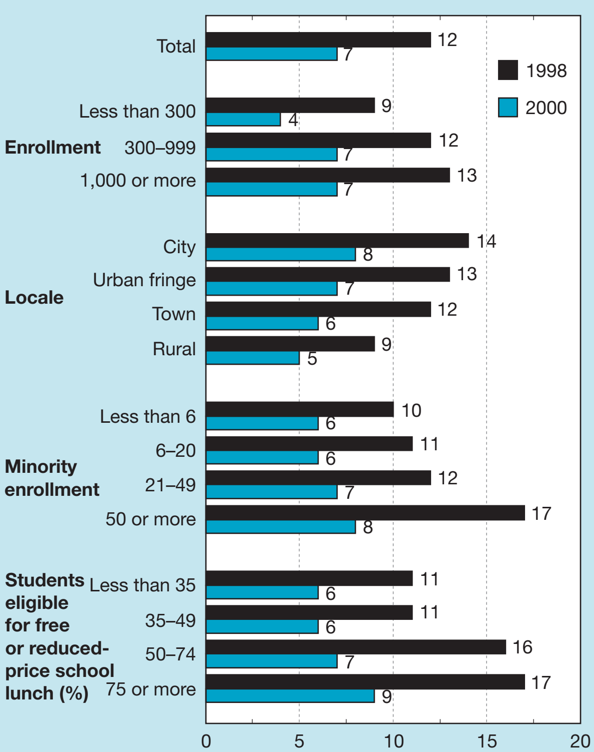
Science & Engineering Indicators – 2002

Access to IT

Computers and Internet access are becoming increasingly available in schools, although the distribution of these resources is not uniform. In 2000, the ratio of students to instructional computers in public schools was 5:1, down from 6:1 in 1999 and a dramatic change from 125:1 in 1983 (NCES 2000d, 2001d). The pace of change is rapid, however, and any measure of access quickly becomes out of date. For example, the ratio of students per instructional computer with Internet access in public schools declined from 12:1 in 1998 to 9:1 in 1999 and then to 7:1 in 2000 (NCES 2001d). Given this rapid degree of change, any data presented in this section run the risk of being a history lesson in disparities in IT access rather than a reporting of current conditions. That said, identifiable disparities can serve as benchmarks for increasing access to technology for all students.

The overall average student-to-computer ratio reported above hides two facts: the distribution of computers per student is skewed (see figure 1-17), and many computers included in that count may be old and have limited usefulness (NCES 2000d). In 1994, for example, 4 percent of the nation's schools had one computer per 4 students, while 46 percent of the schools had one computer per 16.5 students and 10 percent of the schools had one computer per 28.5 students (NCES 2000d). A 1998 study of elementary and secondary schools found that "over half of the computers are out of date.… And in elementary schools almost two-thirds are of limited capacity" (Anderson and Ronnkvist 1999). Older computers often do not have the capacity to link to the Internet or to run current multimedia applications, such as CD-ROM reference and encyclopedia programs (NCES 2000d). Older computers can, however, be used to perform drill and practice sessions and to develop keyboard skills. The ratio of students to instructional computers with Internet access may serve as a reasonable proxy for access to more recent technology.

Figure 1-17.
Ratio of students per instructional computer with Internet access, by school characteristics: 1998 and 2000



SOURCE: National Center for Education Statistics, *Internet Access in U.S. Public Schools and Classrooms: 1994–2000*, NCES 2001-071 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2001c).

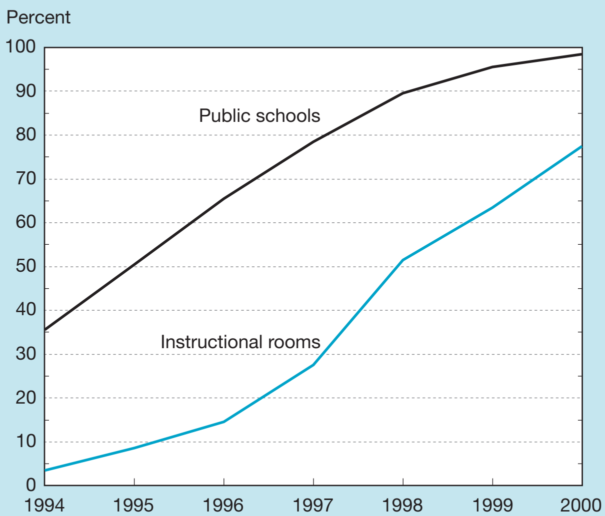
Science & Engineering Indicators – 2002

Although the vast majority of teachers have access to computers somewhere in their schools, they appear more likely to use them in instruction if the computers are located in their classrooms. Nearly all public school teachers (99 percent) reported having computers available somewhere in their schools in 1999 (NCES 2000g); 84 percent had computers available in their classrooms and 95 percent had computers available elsewhere in the school. Thirty-six percent of teachers had one computer in their classrooms, 38 percent reported having two to five computers in their classrooms, and 10 percent reported having more than five computers in their classrooms. Teachers were generally more likely to use computers and the Internet if the computers were located in their classrooms than if they were located elsewhere in the school. Furthermore, teachers and students with more computers or more computers connected to the Internet in their classrooms reported using these technologies more often than teachers with fewer computers or fewer Internet connections.

The Internet can open schools to a variety of external resources, and schools have been using it increasingly. Internet access existed at 35 percent of public schools in 1994, but this statistic soared to 98 percent by 2000 (NCES 2001d). (See figure 1-18.) In 1999, however, access to the Internet existed at only one location in 37 percent of schools, thus making regular instructional use difficult (NCES 2000d). Data on this measure are unavailable for 2000.

Although many schools have computers and Internet access, the distribution of these resources among schools with high and low concentrations of poverty is not uniform. A study based on data from the mid-1990s (Anderson and Ronnkvist 1999) found that schools with high concentrations of poor or minority students have fewer computers and are less likely to have Internet access. Although nationally representative data suggest that this gap is narrowing, the data also show that "large gaps…in the quality of the computer equipment available" still exist (Anderson and Ronnkvist 1999, 16). More recent data provide additional evidence for this trend. For high-poverty schools (those with 75 percent or more students eligible for free or reduced-price lunch), 60 percent of all instructional rooms had Internet access in 2000, up from 5 percent in 1996. Schools with less poverty tended to have a larger percentage of rooms with Internet access—77 percent or higher in 2000, up from 11–17 percent in 1996 (NCES 2001d).

Figure 1-18.
Percentage of public schools and instructional rooms with Internet access: 1994–2000



SOURCE: National Center for Education Statistics, *Internet Access in U.S. Public Schools and Classrooms: 1994–2000*, NCES 2001-071 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2001c).

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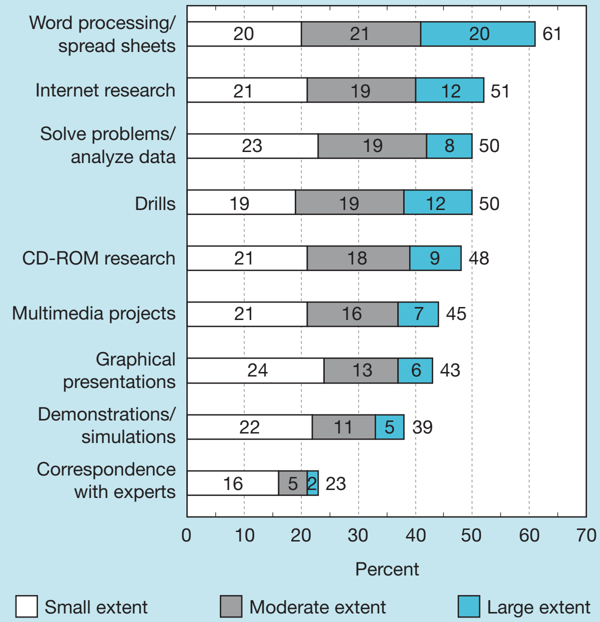
Teacher Use of Technology

Even though computers are common in U.S. schools, many teachers feel unprepared to integrate technology into the subjects they teach. This section reviews data from a 1999 NCES survey on teacher use of computers and the Internet, describes teacher use of education technology in classrooms and schools, and then discusses teacher use of IT at home.

In 1999, approximately half of the public school teachers who had computers or the Internet available in their schools used them for classroom instruction. (See figure 1-19.) Teachers assigned students to use these technologies for word processing or creating spreadsheets most frequently (61 percent), followed by Internet research (51 percent), problem solving and data analysis (50 percent), and drills (50 percent). Additionally, many teachers used computers or the Internet to conduct a number of preparatory and administrative tasks (e.g., creating instructional materials, gathering information for planning lessons) and communicative tasks (e.g., communication with colleagues) (NCES 2000g).

Among those with technology available in their schools, teachers in low-minority and low-poverty schools were generally more likely than teachers in high-minority and high-poverty schools to use computers or the Internet for a wide range of activities, including gathering information at school, creating instructional materials at school, communicating with colleagues at school, and instructing students. For example, 57 percent of teachers in schools with less than 6 percent minority enrollments used computers or the Internet for research compared with 41 percent of teachers in schools with 50 percent or more minority enrollments.

Figure 1-19.
Extent to which public school teachers assign different types of work using computers or Internet: 1999



NOTES: Teachers who reported that computers were not available to them anywhere in the school were excluded from analyses. Details may not add to totals because of rounding.

SOURCE: National Center for Education Statistics, *Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology*, NCES 2000-102 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000g).

Science & Engineering Indicators – 2002

Although the vast majority of teachers have computers at home, there is a strong generational difference associated with how teachers make use of these computers and the Internet. Eighty-two percent of public school teachers reported having a computer available at home, 63 percent of public school teachers had Internet access at home, and 27 percent reported that their schools had a network they could use to access the Internet from home (NCES 2000g). Among teachers with computers available at home, teachers with the fewest years of experience were more likely than teachers with the most years of experience to use computers or the Internet at home to gather information for planning lessons (76 percent compared with 63 percent) and creating instructional materials (91 percent compared with 82 percent). Less experienced teachers were also generally more likely than more experienced teachers to use these technologies to access model lesson plans at school and at home.

Teacher Preparation and Training in IT

Teacher preparation and training to use information technology is a key factor to consider when examining teacher use of computers and the Internet for instructional purposes. In 1999, approximately one-third of teachers reported feeling well prepared or very well prepared to use computers and the Internet for classroom instruction, with less experienced teachers indicating they felt better prepared to use technology than their more experienced colleagues. For many instructional activities, teachers who reported feeling better prepared to use technology were generally more likely to use it than were teachers who indicated that they felt unprepared (NCES 2000g).

Teachers cited independent learning most frequently as the method they used to prepare for technology use (93 percent), followed by professional development activities (88 percent) and assistance from their colleagues (87 percent). Although half of all teachers reported that college and graduate work prepared them to use technology, less experienced teachers were generally much more likely than their more experienced colleagues to indicate that this education prepared them to use computers and the Internet.

Most teachers indicated that professional development activities on a number of topics were available to them, including training on software applications, use of the Internet, and use of computers and basic computer training (ranging from 96 percent to 87 percent). Among teachers reporting that these activities were available, participation was relatively high (ranging from 83 to 75 percent) and more experienced teachers were generally more likely to participate than less experienced teachers. Teachers indicated that followup and advanced training and use of other advanced telecommunications were available less frequently (67 and 54 percent, respectively), and approximately half of the teachers reporting that these two activities were available to them participated in those activities.

Over a three-year period, most teachers (77 percent) participated in professional development activities in the use of computers or the Internet that lasted the equivalent of four days or fewer (i.e., 32 or fewer hours). Teachers who spent more time in professional development activities were generally more likely than teachers who spent less time in such activities to indicate they felt well prepared or very well prepared to use computers and the Internet for instruction (NCES 2000g).

Perceived Barriers to Teacher Use of Technology

Certain characteristics of classrooms and schools, such as equipment, time, technical assistance, and leadership, may act as either barriers to or facilitators of technology use (NCES 2000g). In 1999, barriers to the use of computers and the Internet for instruction most frequently reported by public school teachers were not having enough computers (78 percent), lack of release time for teachers to learn how to use computers or the Internet (82 percent), and lack of time in the schedule for students to use computers in class (80 percent) (NCES 2000g).[12]

Teacher perceptions of barriers to technology use varied by a number of teacher and school characteristics. For example, secondary teachers, teachers in large schools, and teachers in central-city schools were more likely than elementary teachers, teachers in small schools, and teachers in rural schools, respectively, to report that not having enough computers was a great barrier. (See text table 1-6.) Additionally, teachers in schools with more than 50 percent minority enrollments were more likely to cite outdated, incompatible, or unreliable computers as a great barrier than were teachers in schools with less than 6 percent minority enrollments (32 percent compared with 22 percent).

Generally, teachers who perceived lacking computers and time for students to use computers as great barriers were less likely than those who did not perceive these conditions as barriers to assign students to use computers or the Internet for some instructional activities. For example, teachers who reported insufficient numbers of computers as a great barrier were less likely than teachers reporting that this was not a barrier to assign students to use computers or the Internet to a "large extent" for practicing drills (9 percent compared with 19 percent), word processing or creating spreadsheets (14 percent compared with 25 percent), and solving problems and analyzing data (6 percent compared with 13 percent) (NCES 2000g).

Text table 1-6.
Percentage of public school teachers reporting great barriers to use of computers and the Internet for instruction, by type of barrier and school characteristics: 1999

School characteristics	Not enough computers	Outdated, incompatible, or unreliable computers	Internet not easily accessible
All public schools	38	25	27
Elementary	36	27	28
Secondary	43	21	23
Enrollment			
Less than 300	25	24	21
300–999	38	26	27
1,000 or more	46	24	27
Locale			
City	43	29	28
Urban fringe	39	25	27
Town	38	22	23
Rural	31	23	26
Minority enrollment			
Less than 6	35	22	24
6–20	35	22	20
21–49	38	26	27
50 or more	45	32	36

NOTE: Teachers who reported that computers were not available to them in school were excluded from analyses.

SOURCE: National Center for Education Statistics, *Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology,* NCES 2000-102 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, 2000g).

Science & Engineering Indicators – 2002

[12] Includes teachers reporting these as "small, moderate, or great barriers" NCES 2000g, figure 6-1.

Calculator Use in the United States and Other Countries

Handheld calculators are owned by almost every student in the United States and are fully integrated into the teaching of mathematics in many U.S. schools. Since 1985, many calculator models have featured built-in graphing software for enhancing teaching and learning by allowing mathematics students to visualize mathematical functions.

The NCTM Curriculum and Evaluation Standards (NCTM 1989) urge the use of calculators to reduce the time spent on paper and pencil methods of calculating so that students can have more time to work on problems that foster development of underlying concepts. NCTM suggests that by using this approach, students develop a stronger basis for understanding how to approach complex problems. Meanwhile, educators who do not share this view have expressed concern that young children in classrooms where calculators are heavily used may not develop proficiency with basic arithmetic operations. See sidebar, "Calculators and Achievement."

Both the NAEP and TIMSS surveys included questions for teachers and students on their level of calculator use in schools. The TIMSS surveys show that 99 percent of 8th-grade students and 95 percent of 4th-grade students in the United States owned calculators in 1995. The range was from 76 percent in Norway to 95 percent in the United States and the Czech Republic. In the United States, many schools provide calculators for use by students who do not own them. School-owned calculators used in 4th-grade U.S. classrooms increased from 59 percent to 84 percent between 1992 and 1996 (Hawkins, Stancavage, and Dossey 1998).

Classroom use of calculators is more common among U.S. elementary school students than among students in a number of other countries that participated in TIMSS. (See text table 1-7.) Although U.S. teachers were more likely than teachers in most other countries to use calculators in the lower grades, about 30 percent still reported that they never use calculators. However, about the same percentage of these teachers reported using calculators to solve complex problems in 4th-grade classrooms, a proportion similar to that for teachers in Canada and England (Mullis et al. 1997).

By grade 8, classrooms in nearly all countries use calculators for mathematics instruction, although the degree to which they are used varies widely. In 1999, 42 percent of U.S. 8th-grade students reported that they "almost always" use calculators in their mathematics lessons (Mullis et al. 2000). This percentage was higher than the international average (19 percent). Compared to the United States, two nations, the Netherlands and Australia, had a higher percentage of students responding that they almost always use calculators in their mathematics lessons. Eight percent of U.S. 8th-grade students reported never using calculators in their mathematics lessons, which was lower than the international average for students (32 percent).

Official policies on calculator use vary across the countries participating in the TIMSS-R; policies include encouraging unrestricted use, use with restrictions, and banning calculator use entirely (Mullis et al. 2000). Official documents of 23 countries included an explicit policy on the use of calculators. (See text table 1-8 for policies in selected countries.) Seven of these countries reported that their curriculum policy allows unrestricted use of calculators (Belgium, Finland, Hong Kong, Israel, Japan, the Netherlands, and New Zealand), and 14 allow restricted use. In Canada and the United States, policy varied across provinces and states, respectively. Several countries' policies do not permit calculator use in the lower grades of their primary school systems. For example, in Japan, calculators are not permitted until grade 5. Other countries reported that the use of calculators in these lower grades is limited so that students may master basic computational skills, both mentally and using pencil and paper.

Transition to Higher Education

Expectations of college attendance have increased dramatically over the past 20 years, even among low-performing students. More than two-thirds of high school graduates attend college, and a rising proportion have taken a college preparatory curriculum in high school. The use of AP exams to gain college credit in high school has also increased, although research has shown that some colleges are less likely to award AP credit now than in the past. Despite greater numbers of students aiming for college, some college faculty are concerned that today's students are less well prepared in mathematics than previous generations of students. College-level remediation is also on the rise, and policymakers are increasingly concerned about the number of students needing to take remedial courses in college. This section reviews changes in the immediate transition from high school to college over the past 30 years, including changes by sex and by race/ethnicity. The final section discusses the growth of remediation at the college level, a trend that troubles both educators and policymakers who are concerned about the efficacy of the S&E pipeline.

Transition from High School to College

Because most college students enroll in college immediately after completing high school, the percentage of high school graduates enrolled in college the October following graduation is an indicator of the total proportion who will ever enroll in college. College enrollment rates reflect both the accessibility of higher education to high school graduates and their assessments of the relative value of attending college compared with working, entering the military, or pursuing other possibilities.

Overall, immediate college enrollment rates for high school completers increased from 49 to 63 percent between 1972 and 1999. (See figure 1-20.) Much of the growth in these rates between 1984 and 1999 was due to increases in the immediate enrollment rates for females at four-year institutions (see below).

Some differences in immediate enrollment rates among groups of completers have not changed. The gap in rates be-

Text table 1-7.
Student mathematics score and percentage of students and teachers reporting hand-held calculator use in 4th and 8th grades, by country: 1995

	Average mathematics score (mean)		Calculator use and access (%)						
			4th grade				8th-grade teachers		
			Students		Teachers				
Country	4th grade	8th grade	Have calculators at home	Never use in class	Never use in class	Use for complex problems	Never use in class	Use daily	Use for complex problems
Singapore	625	643	93	96	97	1	1	82	82
South Korea	611	607	87	93	86	3	76	1	4
Netherlands	577	541	93	90	85	2	0	81	67
Czech Republic	567	564	95	63	54	8	3	74	80
Austria	559	539	95	96	98	0	2	87	70
Ireland	550	527	95	91	88	3	68	11	7
United States	545	500	95	34	29	26	8	62	76
Hungary	548	537	95	90	78	5	29	60	53
Canada	532	527	95	51	37	23	5	80	86
England	513	506	95	15	8	28	0	83	73
Norway	502	503	95	89	93	1	2	82	72
New Zealand	499	508	95	18	5	50	7	66	70

SOURCES: I. Mullis, M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith, *Mathematics Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 1997); and A. Beaton, M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly, *Science Achievement in the Middle School Years: IEA's Third International Mathematics and Science Study (TIMSS)* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 1996). *Science & Engineering Indicators – 2002*

Calculators and Achievement

Although the National Council of Teachers of Mathematics (NCTM) recommends the integration of calculators into the school mathematics program at all grade levels (NCTM 1989), research on the effect of calculator use on achievement is not definitive. Some studies have concluded that calculator use does not undermine basic skills (Hembree and Dessart 1986, Suydam 1979) and that calculator use has a positive effect on achievement in early grades (B. Smith 1996, Hembree and Dessart 1986). Critics, however, have pointed to deficiencies in the majority of studies supporting calculator use. Many of these studies were of short duration, lasting only a few weeks, and lacked sufficient controls to equate comparable groups or to screen out other influences on student outcomes (Loveless and Diperna 2000).

A recent Brookings Institution study (Loveless and Diperna 2000) examining test results from both the National Assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS) raises additional questions about the influence of calculator use on achievement. For example, in both NAEP and TIMSS, students were asked how often they use calculators in class. On both tests, calculator use is correlated with lower math scores. On the 1996 National NAEP Mathematics Assessment, 4th graders who reported that they used calculators in class every day had the lowest NAEP scores of any response category. Students who reported using calculators only once or twice per month had the highest scores. A similar pattern was evident on 4th-grade TIMSS. Frequent calculator use is negatively correlated with math achievement in several countries. A vast majority of 4th-grade students in the highest scoring nations (Japan, Singapore, and South Korea) report that they never use calculators in math class.

Although Loveless and Diperna acknowledge that these results do not necessarily imply that calculator use results in lower academic achievement (low math skills may actually push individual students to rely on calculators more), their findings suggest that additional, high-quality research on the use of calculators at the elementary level is warranted, particularly because of the equity issues involved. In 1996, black and Hispanic students were about twice as likely as white students to report that they use calculators every day (Loveless and Diperna 2000).

tween those from high- and low-income families persisted for each year between 1990 and 1999. Likewise, completers whose parents had attained a bachelor's degree or higher were more likely than those with parents who had less education to enter college immediately after high school graduation for each year between 1990 and 1999 (NCES 2001b).

Transition Rates by Sex

Females are slightly more likely than males to make an immediate transition from high school to college. Between 1972 and 1999, immediate enrollment rates for female high school graduates increased faster than those for males. (See figure 1-20.) Much of the increase between 1984 and 1999 was due to increases in female enrollment rates at four-year colleges, which rose from 34 to 43 percent over this 15-year period. In 1999, the enrollment rate at four-year institutions was 43 percent for females compared with 41 percent for males. That year, females were about as likely as males to enroll in two-year institutions after high school graduation (both about 21 percent) (NCES 2001b).

Although males and females are similarly prepared to enter the math and science pipeline upon entering college, a large gender gap occurs in the selection of college majors (see sections on achievement and coursetaking in this chapter and chapter 2). However, the divergence in interest in math and science careers may start much earlier.

Text table 1-8.
Policies on calculator usage in selected countries/economies participating in TIMSS-R: 1999

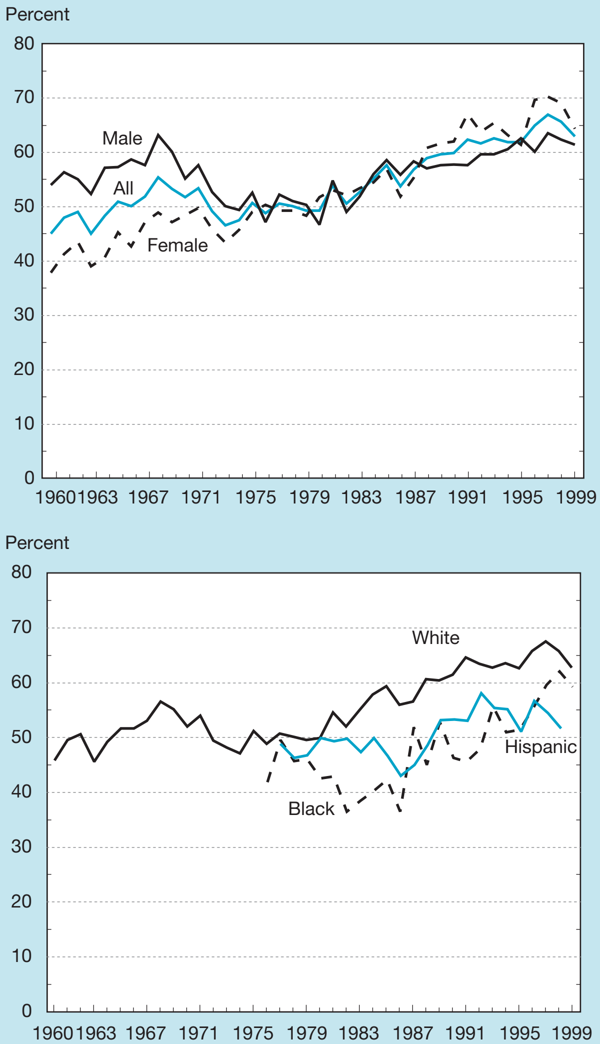
Country/economy	Type of policy	Comments
Australia	Unrestricted	Calculators are unrestricted as a learning tool. Computational skills like mental arithmetic are also promoted.
Belgium (Flemish)	Restricted	Calculators are permitted on a limited basis so that students can master the basic skills of computation and mental calculation. Calculator use increases and is compulsory after grade 9.
Canada	Unrestricted, 2 provinces; restricted, 8 provinces	In general, calculator use is encouraged, except in lower grades in some provinces.
Taiwan	Restricted	Calculators are not allowed on entrance exams, so teachers can limit their use in classroom.
Czech Republic	Restricted	Computational skills are practiced without calculators.
England	Restricted	Calculator use increases as students progress through school. The emphasis is on pupils having a range of skills: calculator, pencil and paper, and mental computation. Graphic calculators are required at higher levels.
Finland	Unrestricted	Although permitted at the lower levels, policy indicates that the use of calculators is more appropriate at the upper levels (grades 7–9).
Hong Kong	Unrestricted	Calculators may be used for exploration only from grades 1 to 6. No restrictions are set on the use of calculators for students from grade 7 onward.
Hungary	Restricted	Calculator use is considered appropriate in higher grades.
Indonesia	Restricted	Calculators are not permitted in lower grades.
Israel	Unrestricted	Calculators are permitted through all school levels (grades 1–12)
Italy[a]		
Japan	Unrestricted	Calculators are not permitted until grade 5.
Netherlands	Unrestricted	Calculators are compulsory at national exam level. In grades 11–12, the graphic calculator is compulsory for mathematics students.
New Zealand	Unrestricted	The policy assumes that calculators will be available and used “appropriately” at all levels.
Russian Federation	Restricted	There is some use of calculators in elementary school. Recommended use of calculators on a level with oral and written calculations in secondary school. Students are not allowed to use calculators for public exams in grades 9 and 11.
Singapore	Restricted	In primary school, students are not allowed to use calculators in mathematics. In secondary school, the use of calculators is allowed from grade 7, although the use is restricted.
Slovenia[a]		
South Korea	Restricted	Currently, calculators are not used in class. However, the new curriculum, to be implemented in 2000/01, recommends the wide use of calculators.
United States	Varies from state to state	

[a]Curriculum does not contain recommendations about use of calculators.

SOURCE: I. Mullis, M. Martin, E. Gonzalez, K.D. Gregory, R.A. Garden, K.M. O’Connor, S.J. Chrostowski, and T. Smith. *TIMSS 1999 International Mathematics Report* (Chestnut Hill, MA: Boston College, TIMSS International Study Center, 2000).

Science & Engineering Indicators – 2002

Figure 1-20.
Percentage of high school graduates enrolled in college the October after completing high school, by sex and race/ethnicity: 1960–99



NOTE: Data for Hispanics are calculated as three-year moving average.

SOURCE: National Center for Education Statistics, *The Digest of Education Statistics 2000*, NCES 2001-034 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2001b).

Science & Engineering Indicators – 2002

Transition Rates by Race/Ethnicity

College transition rates for white and black high school graduates have increased over the past 30 years, while rates for Hispanic graduates have been stable. (See figure 1-20.) Transition rates for white high school graduates increased from 50 percent in the early 1970s to about 60 percent in the mid-1980s and have fluctuated between 60 and 67 percent since then. After a period of decline in the late 1970s and early 1980s, the percentage of blacks enrolling in college immediately after high school graduation rose through the late 1980s, stagnated in the early 1990s, and increased again in the late 1990s. Since 1984, college transition rates for black graduates have increased faster than those for whites, thus closing much of the gap between the two groups. The enrollment rates for Hispanic graduates have shown no consistent growth since 1972, fluctuating between 45 and 65 percent from 1972 to 1997 (NCES 2001b).

The type of institutions that high school graduates first attend can affect their likelihood of completing a bachelor's degree. Students who begin their higher education at a two-year college are far less likely to earn a bachelor's degree than are their counterparts who begin at a four-year college. In 1994, white graduates were twice as likely to enroll in a four-year college as a two-year college after high school, black graduates were about 1.5 times as likely, and Hispanic graduates were equally likely to enroll in a four-year college as a two-year college (NCES 1996b).

Students who initially enroll part time in college are less likely to persist toward a bachelor's degree than those who enroll full time (NCES 1996b). Hispanic high school graduates ages 18–24 were far more likely to be enrolled in college part time, as opposed to full time, than were their white or black counterparts in 1994. (See sidebar, "Who Is Prepared for College?")

Remedial Education in College

Many students enter postsecondary education institutions lacking the reading, writing, or mathematics skills necessary to perform college-level work. Therefore, most institutions enrolling freshmen offer remedial courses to bring these students' skills up to the college level (NCES 2000a). Although some consider remedial courses as one way to expand educational opportunities for students with academic deficiencies, others feel that remedial instruction should be eliminated or strictly limited in four-year institutions.

In 1995, all public two-year and 81 percent of public four-year institutions offered remedial reading, writing, or mathematics courses. Fewer private four-year institutions (63 percent) offered remedial courses in one or more of these subjects. (See figure 1-22.)

Public two-year institutions were more likely than either public or private four-year institutions to offer remedial courses because of their particular mission and the types of students they serve. In 1995, about one-half of public two-year institutions had open admissions compared with less than 10 percent of public and private four-year institutions (NCES 2000a). Freshmen at public two-year institutions were almost twice as likely as their peers at public four-year institutions to enroll in remedial courses in reading, writing, or mathematics (41 versus 22 percent) (NCES 2000a).

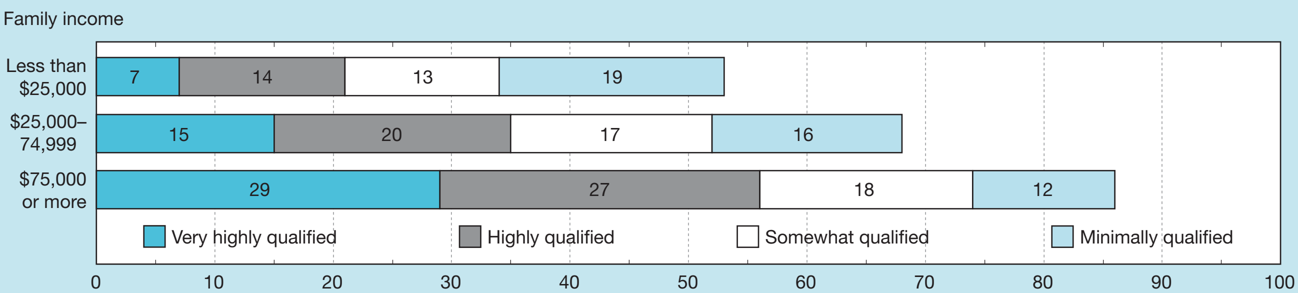
Who is Prepared for College?

High school graduates from low-income families enter four-year institutions at lower rates than their higher income peers (NCES 2000a). Although financial barriers to college attendance exist for many low-income students, another reason for their lower enrollment rate is that they are less qualified academically. (See figure 1-21.) NCES constructed a 4-year College Qualification Index, based on high school grade point average, senior class rank, aptitude test scores from the National Educational Longitudinal Study of 1988, SAT or ACT scores, and a measure of curricular rigor (see NCES 2000a for details). On this index, 86 percent of 1992 high school graduates from families with high incomes ($75,000 or more) were at least minimally academically qualified for admission to a four-year institution compared with 68 percent of those from middle-income ($25,000 to $74,999) and 53 percent from low-income (less than $25,000) families. Moreover, high-income graduates were almost twice as likely as middle-income graduates and four times as likely as low-income graduates to be very highly qualified for four-year college admission. The proportion of college-qualified students was also directly related to their parents' educational attainment.

Asian/Pacific Islander and white graduates have higher average family income and parental education levels than their black and Hispanic counterparts. Reflecting this pattern, Asian/Pacific Islander and white graduates were more likely than black and Hispanic graduates to be at least minimally qualified for four-year college admission. The proportion of very highly qualified graduates was largest among Asians/Pacific Islanders.

SOURCE: NCES 2000a.

Figure 1-21.
Percentage of 1992 high school graduates qualified for admission at a four-year institution, by level of qualification and family income



NOTE: Four-year college qualification index is based on high school grade point average, senior class rank, National Educational Longitudinal Study (NELS) 1992 aptitude test, SAT scores, and a measure of curricular rigor.

SOURCE: National Center for Education Statistics, *The Condition of Education 2000*, NCES 2000-062 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000a).

Science & Engineering Indicators – 2002

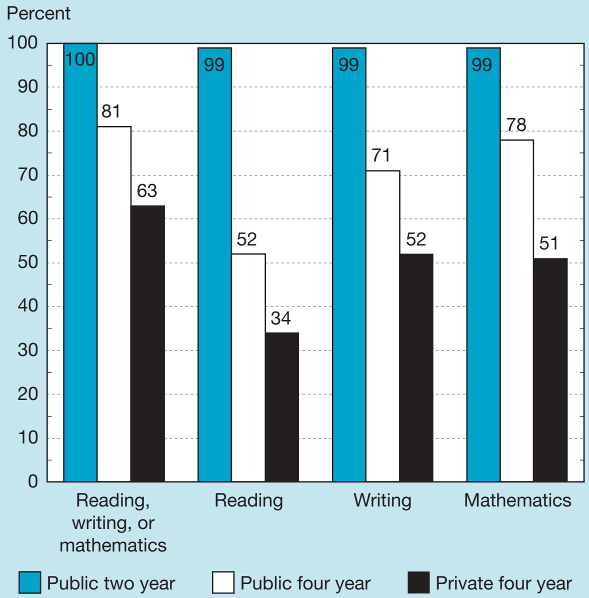
Conclusion

This chapter presented indicators of the status and change in U.S. elementary and secondary schools regarding student achievement, math and science coursetaking, implementation of content standards and state-level testing, curriculum structure and amount of time allocated to math and science compared with other countries, teacher quality (including initial training and professional development), teacher working conditions, access to and use of technology in schools, and transition to higher education. Although these indicators do not tell the whole story, they do highlight improvements in our K–12 education system over the past few decades while pointing to areas of enduring concern.

Observations made about U.S. mathematics and science education in 1947 noted that textbooks were thick and included unnecessary information and that teachers did not have sufficient training in mathematics (NSB 2000). Significant efforts have been made to reform elementary and secondary schools since 1947, such as those stimulated by *Sputnik* in 1957, the National Commission on Excellence in Education in 1983, and the National Education Goals that grew out of the Governor's summit of 1990. The national policy goals and educational standards for mathematics and science education set new and higher expectations for U.S. schools, students, and teachers. The indicators in this chapter were chosen to measure how close the nation has come to meeting those expectations.

A higher proportion of students graduate from high school with advanced courses in mathematics and science than did their counterparts three decades ago. As measured by NAEP, student achievement in mathematics and science has increased since the mid-1970s, although relatively few students are attaining levels deemed Proficient or Advanced by NAGB, and the performance of U.S. students continues to rank substantially below that of students in a number of other countries. Furthermore, the relative performance of U.S. students compared to their counterparts in other countries appears to de-

Figure 1-22.
Percentage of postsecondary education institutions offering remedial courses, by type of course and type of institution: fall 1995



SOURCE: National Center for Education Statistics, *The Condition of Education 2000*, NCES 2000-062 (Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement: 2000a).

Science & Engineering Indicators – 2002

cline as students progress through school and it also affects our most advanced students.

Girls have closed much of the gender gap in mathematics achievement, although a larger share of boys continue to perform at the most advanced levels; the gender gap in science achievement has also narrowed. The gap between high and low performers remains wide, however, and black and Hispanic students continue to perform far below their white counterparts.

An explicit goal of educational standards for mathematics and science is that all students, without regard to gender, race, or income, participate fully in challenging coursework and achieve at high levels. The disparate performance among racial/ethnic groups is still observed when transcripts are examined. Asian/Pacific Islander and white students are much better represented in advanced courses than are black and Hispanic students. Racial/ethnic differences in math and science achievement persist among students taking similar courses in high school, primarily reflecting the large achievement gaps evident before high school entry.

In the 1980s, most states approved policies aimed at improving the quality of K–12 education by implementing statewide curriculum guidelines and frameworks as well as assessments. At present, half of the states require students to pass some form of exit examination to graduate from high school, and others report that they are developing such tests. Teachers remain concerned, however, that standards do not always provide clear guidance regarding the goals of instruction and that schools do not yet have access to top-quality curriculum materials aligned with the standards. Although some states have recently delayed the introduction of high-stakes tests (i.e., tests that students must pass to either graduate or advance a grade), public support for the standards movement remains strong.

Public school teachers generally support the movement to raise standards, but they are less supportive than the general public. The vast majority of public school teachers feel that the curriculum is becoming more demanding of students, although they also feel that new statewide standards have led to teaching that focuses too much on state tests and that a significant amount of "teaching to the test" occurs.

Measuring the extent to which standards are linked to instruction that challenges students is difficult because available methods cannot measure quality directly. Available indicators focus on the amount of time students spend studying a subject (classwork and homework), the content of lessons, and the types of instructional resources used (e.g., textbooks). These data show that although U.S. students appear to receive at least as much classroom time in mathematics and science instruction as students in other nations, instruction in U.S. 8th-grade classrooms tends to focus on the development of low-level skills rather than on understanding and provides few opportunities for students to engage in high-level mathematical thinking.

Improvements in the quality of U.S. education cannot occur without the concurrence of teachers. Research suggests that the following factors are associated with teacher quality: having academic skills, teaching in the field in which the teacher received training, having more than a few years of experience (to be most effective), and participating in high-quality induction and professional development programs. It is still common for students to be taught math and science by teachers without academic training in those subjects, and this mismatch is worse in high-poverty schools.

Salaries for math and science teachers remain well below those of bachelor's and master's degree scientists and engineers in industry. Given that teacher retirements are on the rise, increased salaries provide a means of retaining good teachers and attracting the number of quality teachers needed to replace retirees. The difference between the annual median salaries of all bachelor's degree recipients and teachers has declined over the past 20 years, mainly due to increases in the relative size of the older teaching workforce and in salaries of older teachers.

The role of education technology in U.S. schools has been changing rapidly. Handheld calculators are commonly used in both U.S. homes and classrooms. About one-fourth of 4th-grade teachers and three-fourths of 8th-grade teachers report that they use calculators for solving complex problems. By 2000, nearly all schools reported that at least one computer was linked to the Internet and half of the classrooms had access to the Internet.

Finally, expectations of college attendance have increased dramatically over the past 20 years, even among low-performing students. More than two-thirds of high school graduates attend college, and a rising proportion have taken a college preparatory curriculum in high school. The use of AP exams to gain college credit in high school has also increased, although research has shown that some colleges are less likely to award AP credit now than in the past. College-level remediation is also on the rise, and policymakers are increasingly concerned about the number of students needing to take remedial courses in college. The impact of these changes on the S&E pipeline is addressed in the next chapter.

Selected Bibliography

Achieve, Inc. 2000. *High Standards: Giving All Students a Fair Shot.* Policy Brief. Washington DC.

Achieve, Inc. 2001. *Standards and Accountability: Strategies for Maintaining Momentum.* Policy Brief. Washington DC.

American Association for the Advancement of Science (AAAS), Project 2061. 2000a. “Algebra for All — Not with Today’s Textbooks, Says AAAS.” Press Release. Available at <http://www.project2061.org/newsinfo/press/rl000426.htm>. Accessed 10/24/2001.

———. 2000b. “Big Biology Books Fail to Convey Big Ideas, Reports AAAS’s Project 2061” Press Release. Available at <http://www.project2061.org/newsinfo/press/rl000627.htm>. Accessed 10/24/2001.

———. 1999a. “Heavy Books Light on Learning: Not One Middle Grades Science Text Rated Satisfactory.” Press Release. Available at <http://www.project2061.org/newsinfo/press/rl092899.htm>. Accessed 10/24/2001.

———. 1999b. “Middle Grades Mathematics Textbooks: A Benchmarks-Based Evaluation.” Available at <http://www.project2061.org/matheval/intro.htm>. Accessed 10/24/2001.

American Federation of Teachers (AFT). 2001. *Making Standards Matter 2001*. Washington DC. Available at < http://www.aft.org/edissues/standards/msm2001/>. Accessed 11/26/2001.

Anderson, R.A. 1996. “Study of Curriculum Reform—October 1996.” *Summary Review of Literature*. Available at <http://www.ed.gov/pubs/SER/CurricReform/index.html>. Accessed 10/24/2001.

Anderson, R.E., and A. Ronnkvist. 1999*. The Presence of Computers in American Schools*. Irvine, CA: Center for Research on Information Technology and Organizations, University of California, Irvine.

Ballou, D. 1996. “Do Public Schools Hire the Best Applicants?” *The Quarterly Journal of Economics* February: 97–133.

Baker, D.P., and D.P. Jones. 1993. “Creating Gender Equality: Cross-National Stratification and Mathematical Performance.” *Sociology of Education* 66: 91–103.

Beaton, A., M. Martin, I. Mullis, E. Gonzalez, T. Smith, and D. Kelly. 1996a. *Science Achievement in the Middle School Years: IEA’s Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College, TIMSS International Study Center.

Beaton, A., I. Mullis, M. Martin, E. Gonzalez, D. Kelly, and T. Smith. 1996b. *Mathematics Achievement in the Primary School Years: IEA’s Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College, TIMSS International Study Center.

Belden, Russonello, and Stewart Research and Communications. 2000. *Making the Grade: Teachers’ Attitudes Toward Academic Standards and State Testing: Findings of National Survey of Public School Teachers for Education Week.* Washington, DC.

Becker, H.J. 1997. “The Equity Threat of Promising Innovations: The Internet in Schools.” Paper presented at the annual meeting of the Society for the Psychological Study of Social Issues, Chicago. Available at <http://nsn.bbn.com/dissemination/docs/equity.html>. Accessed March 16, 1999.

———. 1999. *Conditions of Professional Use and Teacher-Directed Student Use Teaching, Learning, and Computing: 1998 National Survey Report #1*. Center for Research on Information Technology and Organizations, The University of California, Irvine.

Berman, P. 1988. “The Charter School Movement.” Paper presented at a discussion sponsored by the California Education Policy Seminar and the California State University for Education Reform, Sacramento, CA.

Blank, R.K., and D. Langeson. 1997. *State Indicators of Science and Mathematics Education 1997: State-by-State Trends and New Indicators from the 1995–96 School Year*. Washington, DC: Council of Chief State School Officers. Available at <http://www.ccsso.org/pdfs/Indicators97.pdf>. Accessed 10/24/2001.

———. 1999. *State Indicators of Science and Mathematics Education 1999: State Trends and New Indicators from the 1997–98 School Year*. Washington, DC: Council of Chief State School Officers. Available at <http://www.ccsso.org/SciMathIndicators99.html>. Accessed 10/24/2001.

Bond, L.A. 1996. Norm- and criterion-referenced testing. Practical Assessment, *Research & Evaluation*, 5(2). Available at <http://ericae.net/pare/getvn.asp?v=5&n=2>. Accessed 10/24/2001.

Bybee, R.W. 1997. “The Sputnik Era: Why Is This Educational Reform Different from All Other Reforms.” Prepared for the symposium “Reflecting on Sputnik: Linking the Past, Present, and Future of Educational Reform,” Washington, DC, October 4, 1997.

California Education Policy Seminar and the California State University Institute for Education Reform Roundtable Proceedings, California State University (CSU). 1998. *Charter Schools: National Concept, California Experience,* Sacramento, CA, October 1, 1997.

Campbell, P.F., and M.L. Johnson. 1995. “How Primary Students Think and Learn.” In I.M. Carl, ed., *Prospects for School Mathematics: Seventy-five Years of Progress,* pp. 21–42. Reston, VA: National Council of Teachers of Mathematics.

Carter, D., and R. Wilson. 1997. *Fifteenth Annual Status Report on Minorities in Higher Education.* Washington, DC: American Council on Education.

Chaney, B. 1995. *Student Outcomes and the Professional Preparation of Eighth Grade Teachers in Science and Mathematic*s. Report prepared by the National Science Foundation. Rockville, MD: Westat, Inc.

Cicourel, A.V., and J. I. Kituse. 1963. *The Educational Decision-Makers*. New York: Bobbs-Merrill.

Coley, R.J., J. Cradler, and P.K. Engel. 1997. *Computers and Classrooms: The Status of Technology in U.S. Schools.* Princeton, NJ: Policy Information Center, Educational Testing Service.

Council of Chief State School Officers (CCSSO). 2000a. *Key State Education Policies on K–12 Education: 2000.* Washington, DC. Available at <http://www.ccsso.org/pdfs/KeyState2000.pdf>. Accessed 10/23/2001.

———. 2000b. *Using Data on Enacted Curriculum in Mathematics & Science: Sample Results from a Study of Classroom Practices and Subject Content.* Washington, DC. Available at <http://www.ccsso.org/pdfs/finalsummaryreport.pdf>. Accessed 10/24/2001.

Council of Chief State School Officers (CCSSO). 2001*. New Tools for Analyzing Teaching, Curriculum, and Standards in Mathematics and Science.* Washington, DC.

Council of the Great City Schools. n.d. *Key Facts: 1997–98 Data About Council Member Districts*. Washington, DC. Available at <http://www.cgcs.org/oldsite/reports/key%5Ffacts/index.cfm>. Accessed 10/24/2001.

Council of the Great City Schools and the College Board. 2001. *Advancing Excellence in Urban Schools: A Report On Advanced Placement Examinations in the Great City Schools.* Washington, DC. Available at <http://www.cgcs.org/oldsite/reports/home/AP_1999.PDF>. Accessed 10/24/2001.

Darling-Hammond, L. 1998. Teachers and Teaching: Testing Policy Hypotheses from a National Commission Report. *Educational Researcher* 27(1): 5–15.

———. 2000. Teacher Quality and Student Achievement: A Review of State Policy Evidence. *Education Policy Analysis Archives* 8(1). Available at <http://olam.ed.asu.edu/epaa/v8n1/>.

DeBoer, G. 1984. "A Study of Gender Effects in the Science and Mathematics Course-Taking Behavior of a Group of Students Who Graduated from College in the Late 1970s," *Journal of Research in Science Teaching* 21:95–103.

Education Week. 1999. "Technology Counts '99: Building the Digital Curriculum." *Education Week* 19 (4/September 23). Available at <http://www.edweek.org/sreports/tc99/articles/summary.htm>. Accessed 10/24/2001.

Education Trust. 1998. *Education Watch 1998. State and National Databook, Vol. II*. Washington, DC: Education Trust.

Ehrenberg, R.G., and D. Brewer. 1994. "Do School and Teacher Characteristics Matter? Evidence from High School and Beyond." *Economics of Education Review* 13(1): 1–17.

Ehrenberg, R.G., and D.J. Brewer. 1995. "Did Teachers' Verbal Ability and Race Matter in the 1960s? Coleman Revisited." *Economics of Education Review* 14(1): 1–21.

Erickson, F. 1975. "Gatekeeping and the Melting Pot: Interaction in Counseling Encounters." *Harvard Educational Review* 45: 44–70.

Eyelon, B., and M.C. Linn. 1988. "Learning and Instruction: An Examination of Four Research Perspectives in Science Education." *Review of Educational Research* 58(3): 251–302.

Ferguson, R. 1991. "Paying for Public Education: New Evidence on How and Why Money Matters." *Harvard Journal of Legislation* 28 (summer): 465–98.

Ferguson, R.F. 1998. "Can Schools Narrow the Black-White Test Score Gap?" In C. Jencks, and M. Phillips, eds., *The Black-White Test Score Gap*. Washington, DC: Brookings Institution Press.

Ferguson, R.F., and H. Ladd. 1996. "How and Why Money Matters: An Analysis of Alabama Schools." In H.F. Ladd, ed., *Holding Schools Accountable: Performance-Based Reform in Education*. Washington, DC: Brookings Institution Press.

Finn, C.E. and M.J. Petrilli. 2000. *The State of State Standards 2000*. Washington DC: The Thomas B. Fordham Foundation. Available at < http://www.edexcellence.net/library/soss2000/2000soss.html#2000> . Accessed 11/26/2001.

Flanders, J.R. 1987. "How Much of the Content in Mathematics Textbooks Is New." *Arithmetic Teacher* 35(1): 18–23.

Fordham, S., and J.H. Ogbu. 1986. "Black Students' School Success: Coping With the 'Burden of Acting White'" *The Urban Review* 18(3): 176–205.

Gamoran, A. 1997. "Curriculum Change as a Reform Strategy: Lessons from the United States and Scotland." *Teachers College Record* 98(4/summer): 608–28.

Geisinger, K.F. 1992. "Testing Limited English Proficient Students for Minimum Competency and High School Graduation." Proceedings of the Second National Research Symposium on Limited English Proficient Student Issues, Focus on Evaluation and Measurement. Washington DC: Office of Bilingual Education and Minority Languages Affairs (OBEMLA). Available at <http://www.ncbe.gwu.edu/ncbepubs/symposia/second/vol2/testing.htm> . Accessed 10/24/2001.

Gitomer, D.H., A.S. Latham, and R. Ziomek. 1999. *The Academic Quality of Prospective Teachers: The Impact of Admissions and Licensure Testing*. Princeton, NJ: Teaching and Learning Division, Educational Testing Service.

Glennan, T.K., and A. Melmed. 1996. *Fostering the Use of Educational Technology: Elements of a National Strategy.* Santa Monica, CA: The RAND Corporation.

Goldhaber, D.D., and D.J. Brewer. 1997. "Evaluating the Effect of Teacher Degree Level on Educational Performance." In W. Fowler, ed., *Developments in School Finance, 1996*, pp. 197–210. NCES 97-535. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Green, P.J., B.L. Dugoni, S.J. Ingels, and E. Camburn. 1995. *A Profile of the American High School Senior.* NCES 95-384. Washington DC: U.S. Department of Education, National Center for Education Statistics.

Greenwald, R., L.V. Hedges, and R.D. Laine. 1996. "The Effect of School Resources on Student Achievement." *Review of Educational Research* 66 (3): 361–96. Available at <http://www.aera.net/pubs/rer/abs/rer663-6.htm>.

Hanson, S.L., M. Schaub, and D.P. Baker. 1996. "Gender Stratification in the Science Pipeline: A Comparative Analysis of Seven Countries," *Gender and Society* 10(3): 271–90.

Hanushek, E.A. 1992. "The Trade-Off Between Child Quantity and Quality." *Journal of Political Economy* 100(1): 84–117.

Hawkins, E., F. Stancavage, and J. Dossey. 1998. *School Policies and Practices Affecting Instruction in Mathematics: Findings From the National Assessment of Educational Progress*. NCES 98-495. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Hembree, R., and D.J. Dessart. 1986. "Effects of Hand-Held Calculators in Pre-College Mathematics Education: A Meta-Analysis." *Journal for Research in Mathematics Education* 17(2): 83–99.

Henke, R.R., X. Chen, and S. Geis. 2000. *Progress through the Teacher Pipeline: 1992–93 College Graduates and Elementary/Secondary School Teaching as of 1997.* NCES 2000-152. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Henke, R.R., X. Chen, and G. Goldman. 1999. *What Happens in Classrooms? Instructional Practices in Elementary and Secondary Schools: 1994–95.* NCES 1999-348. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Henke, R.R., S.P. Choy, X. Chen, S. Geis, and M.N. Alt. 1997. *America's Teachers: Profile of a Profession*, *1993–94.* NCES 97-460. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Henke, R.R., S. Geis, and J. Giambattista. 1996. *Out of the Lecture Hall and into the Classroom: 1992–93 College Graduates and Elementary/Secondary School Teaching.* NCES 96-899. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Heyns, B. 1974. "Social Selection and Stratification Within Schools." *American Journal of Sociology* 79: 89–102.

Ingersoll, R. 1995. *Teacher Supply, Teacher Qualifications and Teacher Turnover: 1990–91*. NCES 95-665. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

———. 1996. *Out-of-Field Teaching and Educational Equality*. NCES 96-040. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs/96040.html>. Accessed 10/24/2001.

———. 1997. "The Problem of Out-of-Field Teaching." *Phi Delta Kappan Online*. Available at <http://www.pdkintl.org/kappan/king9806.htm>. Accessed June 1998.

———. 1999. "The Problem of Underqualified Teachers in American Secondary Schools." *Educational Researcher* 28(2): 26–37. Available at <http://www.aera.net/pubs/er/arts/28%2D02/ingsoll06.htm>. Accessed 10/24/2001.

Interstate New Teacher Assessment and Support Consortium (INTASC). 1991. *Model Standards for Beginning Teacher Licensing and Development: A Resource for State Dialogue*. Washington, DC: Council of Chief State School Officers. Available at <http://www.ccsso.org/intasc.html>.

———. 1994. *Next Steps: Moving Toward Performance-Based Licensing in Teaching.* Washington, DC: Council of Chief State School Officers.

Kelly, E.M., B.H. Suzuki, and M.K. Gaillard. 1999. "Education Reform for a Mobile Population." *Issues in Science and Technology* 15 (summer): 37–9. Available at <http://www.nap.edu/issues/15.4/p_kelly.htm>. Accessed 10/24/2001.

Landess, T. 1996. "The End of the Beginning: The Education Reform Movement From 1990 to 1994. Washington, DC: U.S. Department of Education.." Available from <http://www.ed.gov./pubs/Prog95/pt3back.html>. Accessed 10/24/2001.

Lewis, L., B. Parsad, N. Carey, N. Bartfai, E. Farris, and B. Smerdon. 1999. *Teacher Quality: A Report on the Preparation and Qualifications of Public School Teachers.* NCES 1999-080. U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Loveless, T., and P. Diperna. 2000. "The Brown Center Report on American Education: How Well Are American Students Learning? Focus on Math Achievement." Washington, DC: Brookings Institution.

Maloy, K. 1993. *Toward a New Science of Instruction: Programmatic Investigations in Cognitive Science and Education*. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://www.ed.gov/pubs/InstScience/title.html>. Accessed 10/24/2001.

Martin, M., I. Mullis, A. Beaton, E. Gonzalez, T. Smith, and D. Kelly. 1997. *Science Achievement in the Primary School Years: IEA's Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College, TIMSS International Study Center. Available at <http://www.timss.org/TIMSS1/SciencA.html>.

Monk, D.H., and J. King. 1994. Multi-level Teacher Resource Effects on Pupil Performance in Secondary Mathematics and Science: The Role of Teacher Subject Matter Preparation. In R. Ehrenberg, ed., *Contemporary Policy Issues: Choices and Consequences in Education*. Ithaca, NY: ILR Press.

Mosteller, F., and D.P. Moynihan, eds. 1972. *On Equality of Educational Opportunity*. New York: Random House.

Mullens, J.E., M.S. Leighton, K.G. Laguarda, and E. O’Brien. 1996. *Student Learning, Teacher Quality, and Professional Development: Theoretical Linkages, Current Measurement, and Recommendations for Future Data Collection.* NCES 96-28. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Mullis, I., M. Martin, A. Beaton, E. Gonzalez, D. Kelly, and T. Smith. 1997. *Mathematics Achievement in the Primary School Years: IEA’s Third International Mathematics and Science Study (TIMSS)*. Chestnut Hill, MA: Boston College, TIMSS International Study Center. Available at <http://www.timss.org/TIMSS1/MathA.html>.

———. 1998. *Mathematics and Science Achievement in the Final Year of Secondary School: IEA’s Third International Mathematics Study (TIMSS)*. Chestnut Hill, MA: Boston College, TIMSS International Study Center. Available at <http://www.timss.org/TIMSS1/MathScienceC.html>.

Mullis, I., M. Martin, E. Gonzalez, K.D. Gregory, R.A. Garden, K.M. O’Connor, S.J. Chrostowski, and T. Smith. 2000. *TIMSS 1999 International Mathematics Report*. Chestnut Hill, MA: Boston College, TIMSS International Study Center.

Murnane, R.J., and R. Levy. 1996a. Evidence from 15 Schools in Austin, Texas. In G. Burtless , ed., Does Money Matter? *The Effect of School Resources on Student Achievement and Adult Success*. Washington, DC: Brookings Institution.

Murnane, R.J., and R. Levy. 1996b. *Teaching the New Basic Skills: Principles for Educating Children to Thrive in a Changing Economy*. New York: The Free Press.

Murnane, R.J., and R. Olsen. 1990. The Effects of Salaries and Opportunity Costs on Length of Stay in Teaching. *The Journal of Human Resources* 21(1): 106–124.

Murnane, R.J., and B.R. Phillips. 1981. Learning by Doing, Vintage, and Selection: Three Pieces of the Puzzle Relating Teaching Experience and Teaching Performance. *Economics of Education Review* 1(4): 453–65.

Murnane, R.J., J.D. Singer, J.B. Willett, J.J. Kemple, and R.J. Olson. 1991. *Who Will Teach? Policies That Matter*. Cambridge, MA: Harvard University Press.

National Board for Professional Teaching Standards (NBPTS). 1991. *Toward High and Rigorous Standards for the Teaching Profession: Initial Policies and Perspectives of the National Board of Professional Teaching Standards,* 3rd ed. ED 337440. Detroit, MI.

National Center for Education Statistics (NCES). 1995. *Social Background Differences in High School Mathematics and Science Coursetaking and Achievement.* NCES 95-206. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1996a. *Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, 1995*. NCES 96-854. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs/96854.pdf>.

———. 1996b. *The Condition of Education 1996*. NCES 96-304. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1996c. *Pursuing Excellence: A Study of U.S. Eighth Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context*. NCES 97-198. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1997a. *Advanced Telecommunications in U.S. Public Elementary and Secondary Schools, Fall 1996*. NCES 97-944. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs/97944.html>.

———. 1997b. *NAEP 1996 Trends in Academic Progress*. NCES 97-985. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubsearch/pubsinfor.asp?pubid=97985R>.

———. 1997c. *Pursuing Excellence: A Study of U.S. Fourth Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context*. NCES 97-255. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1998a. *The Condition of Education 1998*. NCES 98-013. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs98/condition98/index.html>.

———. 1998b. *Pursuing Excellence: A Study of U.S. Twelfth Grade Mathematics and Science Teaching, Learning, Curriculum, and Achievement in International Context*. NCES 98-049. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1999a. *The Condition of Education 1999*. NCES 1999-022. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/condition99/>.

———. 1999b. *Digest of Education Statistics, 1998*. NCES 1999-036. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/digest98/>.

———. 1999c. *Dropout Rates in the United States*. NCES 1999-082. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/1999082.pdf>.

———. 1999d. *Generational Status and Educational Outcomes Among Asian and Hispanic Eighth Graders*. NCES 1999-020. Washington DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 1999e. *Predicting the Need for Newly Hired Teachers in the United States to 2008–09*. NCES 1999-026. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/1999026.pdf>.

———. 1999f. *Status of Education Reform in Public Elementary and Secondary Schools: Teachers’ Perspectives*. NCES 1999-045. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/1999045.pdf>.

———. 1999g. *Teachers’ Quality: A Report on the Prepara-*

tion and Qualifications of Public School Teachers. NCES 1999-080. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000a. *The Condition of Education 2000.* NCES 2000-062. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000b. *The Digest of Education Statistics 1999.* NCES 2000-031. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000c. *Entry and Persistence of Women and Minorities in College Science and Engineering Education*. NCES 2000-601. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000d. *Monitoring School Quality: An Indicators Report.* NCES 2001-030. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000e. *NAEP 1999 Trends in Academic Progress: Three Decades of Student Performance.* NCES 2000-469. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000f. *Pursuing Excellence: Comparisons of International Eighth-Grade Mathematics and Science Achievement from a U.S. Perspective, 1995 and 1999.* NCES 2001-028. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000g. *Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology*. NCES 2000-102. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2000h. *Trends in Educational Equity of Girls and Women.* NCES 2000-030. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2001a. *The 1998 High School Transcript Study Tabulations: Comparative Data on Credits Earned and Demographics for 1998, 1994, 1990, 1987, and 1982 High School Graduates.* NCES 2001-498. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———. 2001b. *The Condition of Education 2001.* NCES 2001-072. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/programs/coe/>. Accessed 10/24/2001.

———. 2001c. *The Digest of Education Statistics 2000.* NCES 2001-034. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://www.nces.ed.gov/pubs2001/digest/>. Accessed 10/24/2001.

———. 2001d. *Internet Access in U.S. Public Schools and Classrooms: 1994–2000.* NCES 2001-071. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

———.2001e. *National Education Longitudinal Study: 1988/94, Data Analysis System.* Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://www.nces.ed.gov/das/htm/surveys.html>. Last updated 8/7/01.

———. 2001f. *The Nation's Report Card: Mathematics 2000.* NCES 2001-517. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement. Available at <http://www.nces.ed.gov/nationsreportcard/mathematics/results/>. Accessed 10/24/2001.

National Commission on Excellence in Education (NCEE). 1983. *A Nation At Risk: The Imperative for Educational Reform*. Washington, DC: U.S. Government Printing Office. Available at <http://www.goalline.org/Goal%20Line/NatAtRisk.html>.

National Commission on Teaching and America's Future (NCTAF). 1996. *What Matters Most: Teaching for America's Future.* ED 395 931. New York. Available at <http://www.tc.edu/nctaf/>.

National Council of Teachers of Mathematics (NCTM). 1989. *Curriculum and Evaluation Standards for Schools' Mathematics*. Reston, VA.

———. 1991. *Professional Standards for Teaching Mathematics*. Reston, VA.

National Education Commission on Time and Learning (NECTL). 1994. *Prisoners of Time.* Washington DC. Available at <http://www.ed.gov/pubs/PrisonersOfTime/>. Accessed August 12, 1999.

National Governor's Association Center for Best Practices. n.d. *What is Systemic, Standards-Based Reform?* Available at <http://www.nga.org/center/topics/1,1188,D_413,00.html>. Accessed 3/31/2001.

National Research Council (NRC). 1996. *The National Science Education Standards*. Washington, DC: National Academy Press. Available at <http://www.nap.edu/books/0309064767/html/>.

———. 1998. *Grading the Nation's Report Card : Evaluating NAEP and Transforming the Assessment of Educational Progress* Washington, DC: National Academy Press. Available at < http://www.nap.edu/books/0309062853/html/index.html>.

National Science Board (NSB). 1998. *Science and Engineering Indicators—1998*. NSB 98-1. Arlington, VA: National Science Foundation. Available at <http://www.nsf.gov/sbe/srs/seind98/frames.htm>.

———. 1999. *Preparing Our Children: Math and Science Education in the National Interest*. NSB 99-31. Arlington, VA: National Science Foundation. Available at <http://www.nsf.gov/nsb/documents/1999/nsb9931/nsb9931.htm>.

———. 2000. *Science and Engineering Indicators—2000*. NSB 00-1. Arlington, VA: National Science Foundation. Available at <http://www.nsf.gov/sbe/srs/stats.htm>.

National Science Foundation (NSF). 1997a. "Foundations: A Monograph for Professionals in Science, Mathematics, and Technology Education." In *The Challenge and Promise of K-8 Science Education Reform, Volume 1*. NSF 97-76.

Washington, DC. Available at <http://www.nsf.gov/pubs/1997/nsf9776/nsf9776.pdf>.

———. 1997b. *Women and Science: Celebrating Achievements, Charting Challenges*. Conference report. NSF 97-75. Washington, DC.

National Science Teachers Association (NSTA). 1992. *Scope, Sequence and Coordination: Content Core*. Washington, DC. Available at <http://dev.nsta.org/ssc/>.

North Central Regional Educational Laboratory (NCREL). n.d. Available at <http://www.ncrel.org/>. Accessed March 1999.

O'Sullivan, C.Y., I.R. Weiss, and J.M. Askew. 1998. *Students Learning Science: A Report on Policies and Practices in U.S. Schools*. Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Oakes, J. 1985. *Keeping Track: How Schools Structure Inequality*. New Haven, CT: Yale.

Oakes, J., A. Gamoran, and R. Page. 1992. "Curriculum Differentiation: Opportunities, Outcomes, and Meanings." In P.W. Jackson, ed., *Handbook of Research on Curriculum*. New York: Macmillan Publishing.

Odden, A., and C. Kelley. 1997. *Paying Teachers for What They Know and Do: New and Smarter Compensation Strategies To Improve Schools*. ED 404 312. Thousand Oaks, CA: Corwin Press..

Organisation for Economic Co-operation and Development. 2000. *Education at a Glance 2000: OECD Indicators.* Paris.

Porter, A.C., J. Smithson, and E. Osthoff. 1994. "Standard Setting as a Strategy for Upgrading High School Mathematics and Science." In R.F. Elmore and S.H. Fuhrman, eds., *The Governance of Curriculum: The 1994 ASCD Yearbook.* Alexandria VA: Association for Supervision and Curriculum Development), 138–66.

President's Committee of Advisors on Science and Technology. 1997. *Report to the President on the Use of Technology to Strengthen K–12 Education in the United States*. Washington, DC: The White House.

Public Agenda. 2000. *Survey Finds Little Sign of Backlash Against Academic Standards or Standardized Tests.* New York.

Public Agenda Online. 2001. *Reality Check 2001*. New York. Available at <http://www.publicagenda.org/specials/rc2001/ reality.htm>. Accessed 10/23/2001.

Reese, C.M., K.E. Miller, J. Mazzeo, and J.A. Dossey. 1997. *NAEP 1996 Mathematics Report Card for the Nation and the States.* Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Rivkin, S.G., E.A. Hanushek, and J.F. Kain. 1998. "Teachers, Schools and Academic Achievement." Paper presented at the Association for Public Policy Analysis and Management, New York City.

Rosenbaum, J.E. 1976. *Making Inequality*. New York: Wiley.

———. 1980. "Track Misperceptions and Frustrated College Plans: An Analysis of the Effects of Tracks and Track Misperceptions in the National Longitudinal Survey." *Sociology of Education* 53: 74–88.

Sanderson, A., B. Dugoni, K. Rasinski, J. Taylor, and C.D. Carroll. 1996. *Descriptive Summary Report.* NCES 96-175. Washington DC: U.S. Department of Education, National Center for Education Statistics.

Schmidt, W.H., C.C. McKnight, and S.A. Raizen. 1997. *A Splintered Vision: An Investigation of U.S. Science and Mathematics Education*. Boston, MA: Kluwer Academic Publishers.

Sells, L.W. 1978. "The Forum: Mathematics—A Critical Filter. *The Science Teacher* 1–4S(2): 28–9.

Shymansky, J.A., W.C. Kyle, Jr., and J.M. Alport. 1983. "The Effects of New Science Curricula on Students Performance." *Journal of Research in Science Teaching* 20(5): 387–404.

Smith, B. 1996. *A Meta-Analysis of Outcomes From the Use of Calculators in Mathematics Education.* Texas A&M doctoral dissertation 101.

Smith, J. 1996. "Does an Extra Year Make Any Difference? The Impact of Early Access to Algebra on Long-Term Gains in Mathematics Attainment." *Educational Evaluation and Policy Analysis* 18(2): 141–53.

Smith, M.S., and J.A. O'Day. 1991. "Systemic School Reform." In S. Fuhrman and B. Malen, eds., *The Politics of Curriculum and Testing, 1990 Yearbook of the Politics of Education Association.* Washington, DC: Falmer Press, 233–67.

Smylie, M.A. 1996. "From Bureaucratic Control to Building Human Capital: The Importance of Teacher Learning in Education Reform." *Educational Researcher* 25(9): 9–11.

Sparks, D., and S. Loucks-Horsley. 1990. "Models of Staff Development." In W.R. Houston, ed., *Handbook of Research on Teacher Education,* pp. 234–50. New York: Macmillan Publishing.

Spillane, J.P., and J.S. Zeuli. 1999. "Reform and Teaching: Exploring Patterns of Practice in the Context of National and State Mathematics Reforms." *Educational Evaluation and Policy Analysis* 21(1): 1–27. Available at <http://www.aera.net/pubs/eepa/abs/eepa2111.htm>.

Stigler, J.W., and H.W. Stevenson. 1991. "How Asian Teachers Polish Each Lesson to Perfection." *American Educator* 1(1): 12–47.

Stigler, J.W., P. Gonzales, T. Kanaka, S. Knoll, and A. Serrano. 1999. *The TIMSS Videotape Classroom Study: Methods and Findings from an Exploratory Research Project on Eighth-Grade Mathematics Instruction in Germany, Japan, and the United States*. NCES 1999-074. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement. Available at <http://nces.ed.gov/pubs99/timssvid/index.html>.

Suydam, M.N. 1979. "The Use of Calculators in Pre-College Education: A State-of-the-Art Review." Columbus, OH: Calculator Information Center. ERIC Document Reproduction Service No. ED 171 573.

U.S. Department of Education, National Center for Education Statistics, National Assessment of Education Progress. n.d. Summary Data Tables. Available at <http://nces.ed.gov/nationsreportcard/tables/>.

Valdivieso, R., and S. Nicolau. 1992. *Look Me in the Eye: A*

Hispanic Cultural Perspective on School Reform. ED 362 342.Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement.

Vance, V.S., and P.C. Schlechty. 1982. The Distribution of Academic Ability in the Teaching Force: Policy Implications. *Phi Delta Kappan* 22–27.

Wenglinsky, H. 1998. *Does It Compute? The Relationship Between Educational Technology and Student Achievement in Mathematics.* Policy Information Report. Princeton: Educational Testing Service.

White, K. 1999. "NRC Report Calls for Voucher Experiment." *Education* (September 15): 3.

Williams, C. 2000. *Internet Access in Public Schools: 1994–99.* NCES 2000-086. Washington, DC: U.S. Department of Education, National Center for Education Statistics, Office of Educational Research and Improvement.

Wise, A.E. 1989. "If We Are Ever To 'Professionalize' School Teaching, Universities Must Redesign Education Programs." EJ 395 990. *The Teacher Educator* 24(4): 29–32.

Wise, A.E., and Leibrand, J. 1996. "Profession-Based Accreditation." *Phi Delta Kappan* 78(1): 202–6.